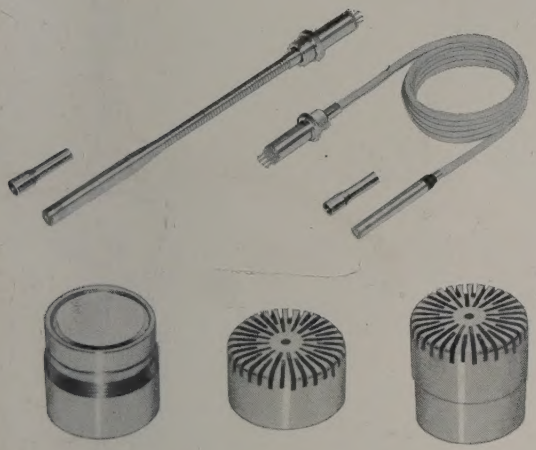
4133/34

INSTRUCTIONS AND APPLICATIONS

Half-inch Condenser Microphones

Microphone Cartridges Type 4133/4134
Cathode Followers Type 2614/2615
Accessories



Precision Condenser Microphones for measurement purposes. Each microphone is calibrated individually and has a sensitivity of approximately 1 mV/μbar. Frequency range of calibration 20 Hz – 40,000 Hz.

Accelerometers
Acoustic Standing Wave Apparatus
Artificial Ears
Artificial Voices
Audio Frequency Response Tracers
Audio Frequency Spectrometers
Audio Frequency Vacuum-Tube Voltmeters
Automatic A. F. Response and Spectrum Recorders
Band-Pass Filter Sets
Beat Frequency Oscillators
Complex Modulus Apparatus
Condenser Microphones
Deviation Bridges
Distortion Measuring Bridges
FM-Tape Recorders
Frequency Analyzers
Frequency Measuring Bridges
Hearing Aid Test Apparatus
Heterodyne Voltmeters
Level Recorders
Megohmmeters
Microphone Accessories
Microphone Amplifiers
Microphone Calibration Apparatus
Mobile Laboratories
Noise Generators
Noise Limit Indicators
Pistonphones
Polar Diagram Recorders
Preamplifiers
Precision Sound Level Meters
Recording Paper
Strain Gage Apparatus and Accessories
Stroboscopes
Variable Frequency Rejection Filters
Vibration Pick-ups
Vibration Pick-up Preamplifiers
Wide Range Vacuum Tube Voltmeters
Vibration Programmers
Vibration Control Signal Selectors
Vibration Control Generators
Vibration Meters

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Half-inch

Condenser Microphones

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0. Introduction

Purpose of the Half-inch Condenser Microphone.

The B & K Half-inch Condenser Microphones are designed for precision sound pressure measurements. Their range of application covers the whole of the audible frequencies (20 Hz to 40 kHz*) and of pressure levels (32 dB to 160 dB). Their most outstanding feature is excellent long-term stability under a great range of environmental conditions and especially their insensitivity to temperature variations. They are therefore suited for field measurements, though their accuracy of calibration matches laboratory standard requirements. An extensive series of accessories herein described provides a great measuring versatility.

Principle of the Condenser Microphone.

A condenser microphone consists essentially of a thin metallic diaphragm mounted in close proximity to a rigid back plate. Diaphragm and back plate are electrically insulated from each other and constitute the electrodes of a capacitor. See Fig. 0.1. Housing and insulator form with the diaphragm a closed chamber, which is only in communication with the outside for slow static ambient pressure variations. When the microphone is exposed to a sound pressure, the diaphragm is submitted to an alternating force proportional to the pressure and the diaphragm area. The consequent movement of the diaphragm varies the capacity, and these variations are transduced into an AC voltage component if a constant charge is present between the electrodes. The charge is obtained by means of a stabilized DC polari-

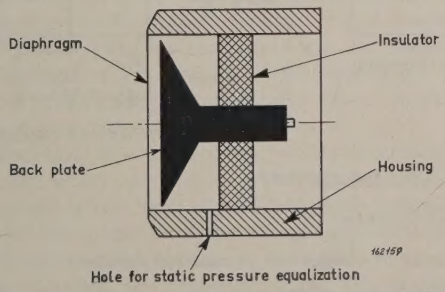


Fig. 0.1. Schematic construction of a condenser microphone cartridge.

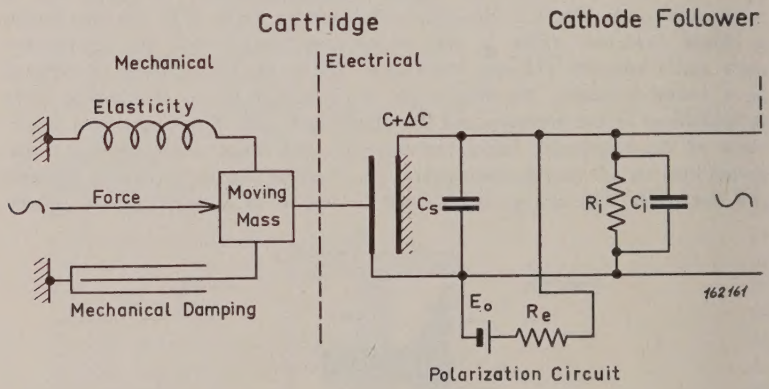
*) Hz international
c/s used in United Kingdom and U.S.A.

zation voltage, and it remains constant as long as the charging time constant of the circuit is much longer than the period of the sound pressure variations. It is possible by careful design to maintain the proportionality of the AC output voltage to the sound pressure within a wide frequency range and an extended dynamic range. The widest linear frequency range for the pressure response is obtained if the resonance of the mechanical system (diaphragm) is critically damped. This damping, which is due to the back and forth movement of the air contained between diaphragm and back plate, is determined by the shape of the back plate, the mechanical tension of the diaphragm and the distance between diaphragm and back plate.

The low frequency limit of the linear range is set by the "cut-off" (or time constant) of the microphone cartridge circuit. Referring to the schematic diagram of Fig. 0.2 the cut-off frequency is equal to:

$$\frac{1}{2\pi\,(C + C_s + C_i)\dfrac{R_i R_e}{R_i + R_e}}$$

Since the sensitivity of the microphone is determined by the relative variation of capacity $\Delta C/(C + C_s + C_i)$, the total parallel capacity should be made as small as possible. The first amplifier stage is therefore built in the same housing as the microphone. A cathode follower stage is employed, because



C = Polarized cartridge capacity

ΔC = Variation of capacity

C_s = Stray capacity of connection to cathode follower

$R_i C_i$ = Input impedance of cathode follower

Fig. 0.2. Simplified diagram of the Condenser Microphone. (The electrical ***leakage in the cartridge is neglected).***

small parallel capacity requires high R_1 and R_e in order to obtain a satisfactory low limiting frequency.

Definitions of Free-field and Pressure Response.

The *Free-field Response* of a microphone is the ratio of the RMS output voltage to the RMS sound pressure existing in the free field at the microphone location with the microphone removed from the sound field.

The *Pressure Response* of a microphone is the ratio of the RMS output voltage to the RMS sound pressure, uniformly applied over the diaphragm.

The two definitions coincide for a microphone having negligible dimensions with respect to the sound wavelength. In the case of the B&K half-inch microphones this is practically fulfilled up to about 2600 Hz, where the wavelength attains ten times the diameter of the microphone (i.e. 127 mm). The difference in response is then less than half a decibel.

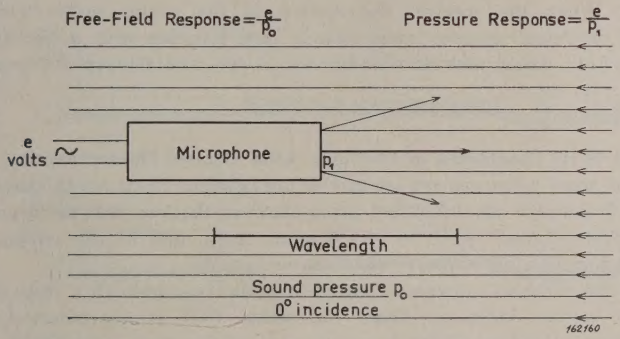


Fig. 0.3. Definitions of Free-field and Pressure Response.

At higher frequencies the diffractions of the sound waves on the microphone produce an appreciable change in the resulting sound pressure acting on the microphone diaphragms as illustrated in Fig. 0.3. The difference $p_1 - p_0$, called *free-field correction,* depends on the orientation of the microphone with respect to the direction of propagation of the sound and on the external dimensions of the microphone (in particular those of the front and of fitted protective grids or "nose cones").

The free-field behaviour of a microphone is thus described by means of a set of free-field correction curves for various incidences, which have been measured on a model of the microphone (see B&K Technical Review Nos. 1 & 2-1959), and which should be added to the pressure frequency curve of the microphone in each particular case.

For microphones intended for free-field work it is possible to give the diaphragm resonance such a damping that the normal incidence free-field corrections are compensated for up to frequencies well above the resonance frequency, in order to obtain the flattest possible frequency response.

Random Incidence Response (Diffuse Field Response).
The random incidence response of a microphone at a given frequency is the root-mean-square value of the free field sensitivity for all angles of incidence of the sound wave. It corresponds to the diffuse field sensitivity of the microphone, the diffuse field being a sound field in which the sound energy density is uniform and the mean acoustic power per unit area is the same in all directions. The International Electrotechnical Commision (publication no. 123. § 8.2) has given a practical rule for the calculation of the random incidence sensitivity from the free-field sensitivities at definitive angles, with coefficients proportional to the relative solid angles. (See page 17).
Figs. 1.3, 1.4, 2.2 and 2.6 show the random incidence frequency response of the different B & K half-inch microphone combinations.
These curves should be taken into consideration in the case of measurements in very reverberant rooms giving rather diffuse field conditions.
However, when the spectral distribution of the sound varies with the angle of incidence, correct integration is only possible with a microphone which is both linear and omnidirectional in the whole frequency range of interest.

Response to Be Considered in Ordinary Noise Control Measurements.
In practice most measurements are carried out in sound fields whose characteristics are in between the definitions given above of the *free field* corresponding to a perfectly "dead" room or 100 % open space, and of the *diffuse field* corresponding to a perfectly reverberant room.
Consider the common example of sound level measurements in a large typing office at various locations. There the sound field is approximately free (predominant direction of the acoustic energy flow) near a particular typewriter, and diffuse (if no predominant reflected wave) near the boundaries of the room.
The frequency response of the microphone is thus changing from one position to the other. This change is, however, only important at frequencies above 5 kHz for the half-inch microphones, as seen in Fig. 1.3, and will not normally influence the measurements with the exception of the case of "noisiness" (Noys or PN dB) measurements.
In intermediate positions, it is practically impossible to predict the nature of the field, or which incidences should be considered.
A microphone which is omnidirectional at least up to 10 kHz is then obviously advantageous. Then the random incidence response is of course identical to the free-field response which is the same at all incidences. This point is therefore stated in the standards for sound level meters (e.g.: IEC 123, § 5.1). Omnidirectional microphones are also necessary in the case of rapidly moving sound sources (aeroplanes, motorcars, etc.).
The omnidirectivity of the 4133 microphone is improved when provided with a nose cone. See Figs. 2.2—2.4.

1. Description

General

A complete microphone consists of a microphone cartridge and a cathode follower for impedance conversion, allowing long cables and relatively low input impedance amplifiers to be used between the microphone and the measuring instrument. The microphone cartridge is screwed onto the housing of the cathode follower making a small, rugged unit. Fig. 1.1.

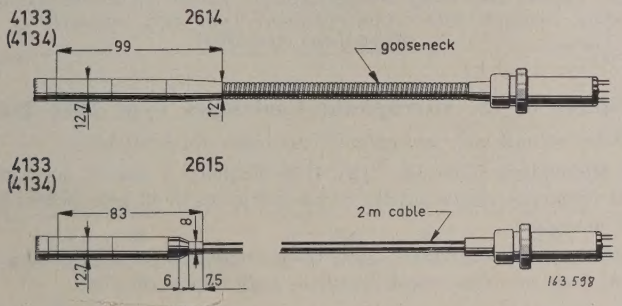


Fig. 1.1. Complete Microphone, consisting of Microphone Cartridge Type 4133 or 4134 and Cathode Follower Type 2614 or 2615. The dimensions are given in mm. (1 mm = 0.03937"). Cartridge dimensions are given on p. 10.

The microphones may be directly connected to the different B&K measuring instruments which are provided with a "Condenser Microphone" input socket fitting the microphone connecting plug. Stabilized plate and heater voltages for the cathode follower and polarization voltage for the cartridge are available on this seven-pin socket. The microphones may also be used with other equipment when operated from a Microphone Power Supply Type 2801 which provides the necessary voltages in the same conditions as the measuring instruments, or with the Battery-driven Cathode Follower Type 2630 (see Accessories). For free-field and room-acoustic measurements, the microphones should be placed remote from the measuring instruments, since these would often disturb the sound field because of their non-negligible dimensions. A microphone stand and different types of extension cables are available for this purpose, see Accessories. An example of measuring equipment is shown in Fig. 1.2.

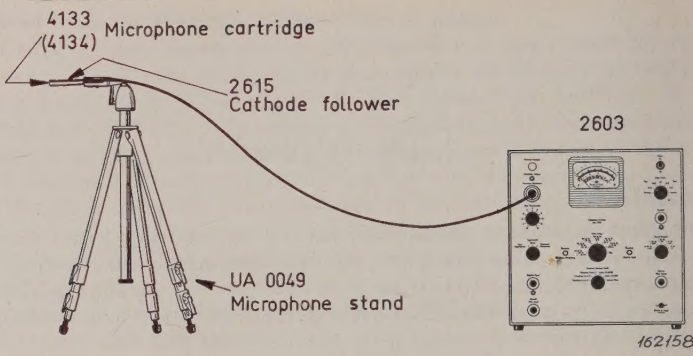


Fig. 1.2. Typical measuring arrangement for sound measurements: half-inch microphone equipped with cathode follower Type 2615 connected to a B & K Microphone Amplifier.

Description of the Microphone Cartridges Type 4133 and 4134.

Two different half-inch microphone cartridges are available:

(1) the Microphone Cartridge Type **4133** featuring a normal incidence free-field frequency characteristic which is flat up to 40 kHz (with protecting grid mounted).

(2) the Microphone Cartridge Type **4134** presenting a pressure (and/or diffuse field) frequency characteristic which is flat up to 20 kHz.

The two cartridges have basically the same mechanical construction and differ only in the **damping of the diaphragm resonance.** The resonance is over-damped in the case of Type 4133, in such a way that the normal incidence free-field pressure increase is compensated by the decrease of pressure sensitivity up to 40 kHz. See Fig. 1.3. In the case of Type 4134 the resonance is approximately critically damped in order to obtain the flattest possible pressure and random incidence frequency response. See Fig. 1.4. The resonance frequency, which is approximately the same for the two cartridges, is around 25 kHz. The damping is controlled by means of appropriate holes in the back plate and by adjusting the spacing and the tension of the diaphragm.

Towards the low frequencies the response of the cartridges is only affected by the influence of the **pressure equalizing arrangement.** This arrangement consists of a capillary leakage hole through which the equalization of the static air pressure on both sides of the diaphragm is obtained at a suitable rate. The influence of ambient pressure (or altitude) variations on the microphone sensitivity has been minimized by proper design of the pressure equalization hole. The equalization hole is situated in front of the grid- and coupler mounting-thread. The pressure equalization is then obtained also

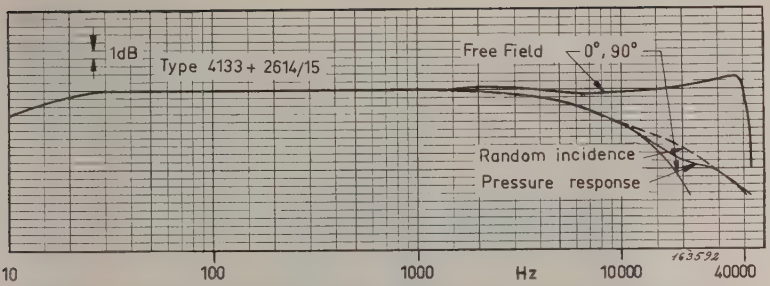


Fig. 1.3. Typical frequency characteristics of the Half-inch Microphone equipped with a Cartridge Type 4133.

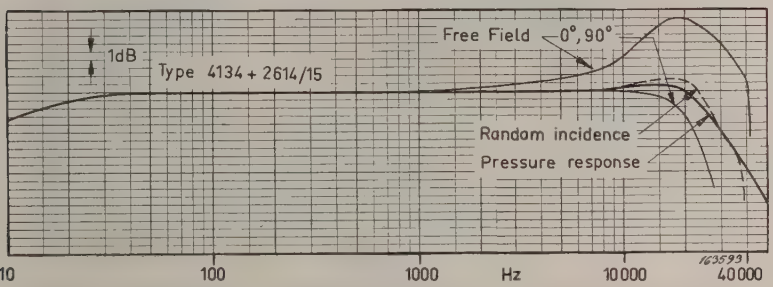


Fig. 1.4. Typical frequency characteristics of the Half-inch Microphone equipped with a Cartridge Type 4134.

in the case of closed cavity measurements. In addition, the temperature inside the microphone being a few degrees higher than the temperature at the equalization opening due to the heat generated by the cathode follower, this prevents moisture condensation taking place inside the cartridge. The time constant of the pressure equalization of Types 4133—4134 is around 0.1 second. This corresponds to a —3 dB cut-off frequency of 1 Hz to 4 Hz, and will not influence the measurements, since the —3 dB low frequency cut-off of the complete microphone is around 10 Hz.

The mechanical construction of the cartridges is shown in Fig. 1.5. The choice of the materials and the design of the suspensions of the different parts are made principally with a view to obtaining the best possible long-term stability and temperature independency of the sensitivity. The cartridges are subjected to a complete artificial aging process during manufacture. The basic parts are made of high nickel alloy (K-Monel). The insulator used is silicone treated quartz and for guaranteeing a disturbance-free connection to the cathode follower gold-plated contacts are used.

The diaphragm is made of a 4 μ thick nickel plate and is mounted at a

distance of 22 μ from the back plate. This distance is reduced to 20 μ when the 200 V polarization voltage is applied. The **polarized cartridge capacity,** which is of the order of 20 pF, is measured individually for each cartridge (see the calibration chart). The insulation is verified as higher than 10^5 MΩ

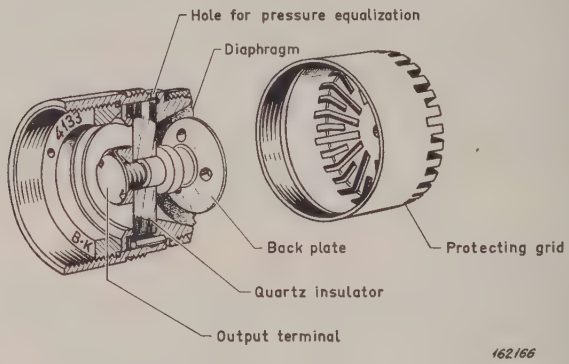


Fig. 1.5. Exploded view of a 1/2″ microphone cartridge.

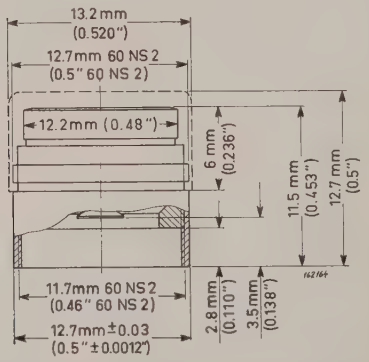


Fig. 1.6. Dimensions of the 1/2″ microphone cartridges Type 4133-4134.

Cleansing of the Microphone Diaphragm.

CAUTION. On no account should the diaphragm which is only 4 μ (0.00016″) thick come into contact with fingers or other objects. The protecting grid should only be removed when absolutely necessary. This grid is an effective protection against mechanical damage but cannot stop liquids or dust from falling on the diaphragm. Should the diaphragm become contaminated it may be dried off with cotton-wool or a very soft paint-brush, using great care, and if necessary a proper solvent. The diaphragm will not normally corrode, but any appreciable added mass will change the frequency response.

Description of the Cathode Followers Type 2614 and 2615.

The Cathode Followers Type 2614 and 2615 are designed for connection to the B & K Condenser Microphone Cartridges or Accelerometers, transforming the high source impedance of the transducer to the relatively low output impedance required for the use of long cables between the microphone and the succeeding measuring instrumentation.

Fig. 1.7. Cathode Followers Type 2614 and 2615, with included input adaptor.

The Cathode Followers are electrically identical. However, the mechanical construction is different, in that the Cathode Follower Type 2614 is fitted to a flexible 20 cm long goose-neck, while Type 2615 is supplied with a 2 m long multicore cable*) Fig. 9. Their outside diameter is 12.7 mm as that of the microphone cartridges and the length of the cylindrical section is approximately 7 cm (2¾″). See also Fig. 1.1.

The components, which are compactly mounted on a teflon base, have been carefully selected in order to ensure high operating stability under the most severe environments. The vacuum tube meets the Mil-EIC specifications.

The electrical components have been divided into two groups. Those belonging to the high impedance input circuit are mounted in the main housing,

*) The 2 m long cable gives an extra capacity of 600 pF in the output of Type 2615.

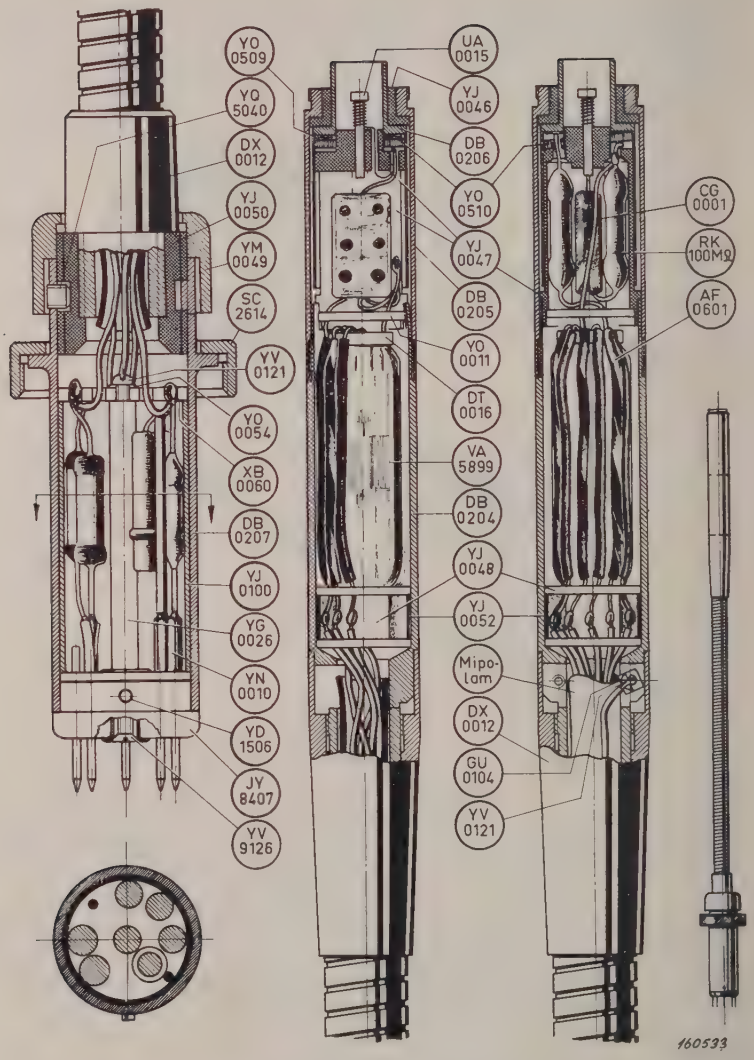
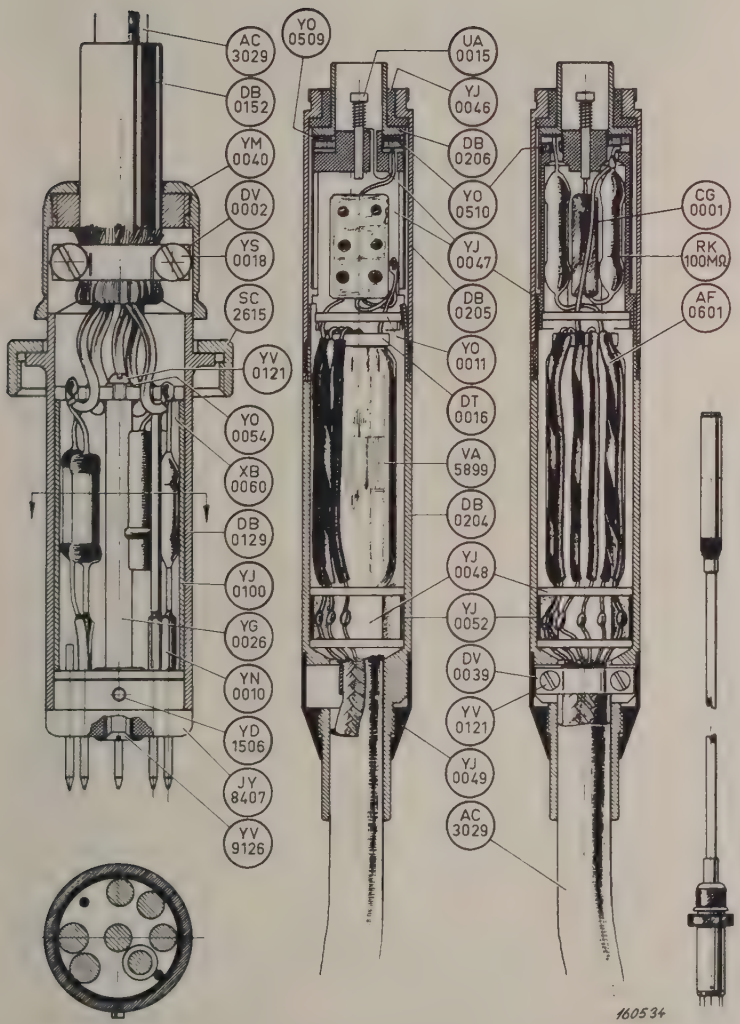


Fig. 1.8. Cross section of the cathode followers with part numbers. (a) Type 2614.


AC 3029
DB 0152
YM 0040
DV 0002
YS 0018
SC 2615
YV 0121
YO 0054
XB 0060
DB 0129
YJ 0100
YG 0026
YN 0010
YD 1506
JY 8407
YV 9126
YO 0509
UA 0015
YJ 0046
DB 0206
YO 0510
YJ 0047
DB 0205
YO 0011
DT 0016
VA 5899
DB 0204
YJ 0048
YJ 0052
DV 0039
YV 0121
YJ 0049
AC 3029
CG 0001
RK 100MΩ
AF 0601
160534

(b) Type 2615.

while all parts on the low impedance side have been placed in the connecting plug, see Fig. 1.8—1.9.

Before mounting each tube is tested for sensitivity to shock and during the final tests the cathode followers are exposed to a sound pressure of 130 dB where their signal/microphonics ratio is checked throughout the frequency range 20—20ooo Hz. This ratio is greater than 40 dB with reference to a microphone with a sensitivity of 1 mV/μbar. See Fig. 1.10.

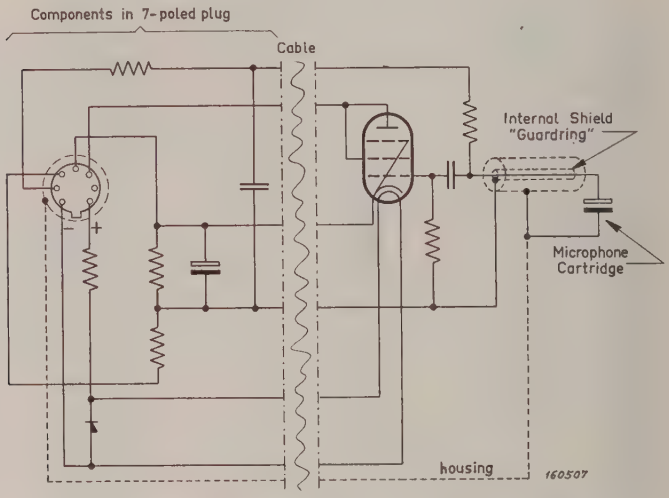


Fig. 1.9. Basic diagram of the cathode followers showing the principle of the "guard ring" system.

The input circuitry is internally screened by means of a "guard ring" which is connected to the cathode of the tube. In this way the input capacity is reduced to an absolute minimum. The guard ring is extended to the top of the cathode follower which allows the use of low capacity extension connectors between microphone cartridge and cathode follower. The Cathode Follower Type 2614 can be mounted directly on the input socket of one of the B & K Microphone Amplifiers, or Frequency Analysers, but for most practical purposes it will be connected via a seven conductor extension cable. When used with an extension cable it can be mounted on the B & K microphone stand, likewise Type 2615.

The capacity of the extension cables will, to a certain extent, load the cathode follower and lower the high frequency cut-off point. It will, furthermore, cause distortion at high sound pressure levels. This will only be of importance when very long cables are used. The relationship between high

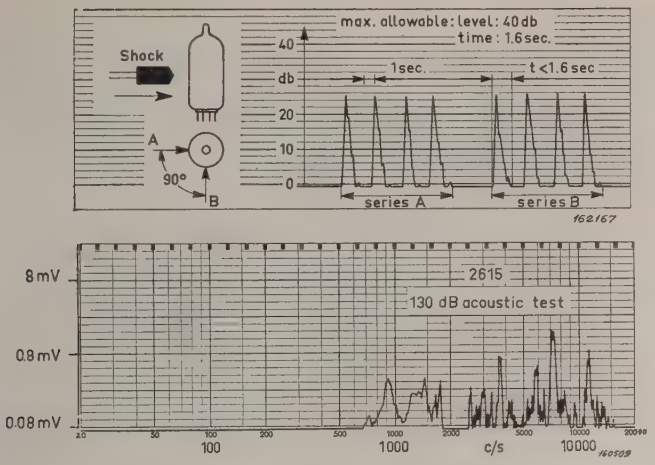


Fig. 1.10.

(a) Test of a tube EF 731. Microphonics are excited by means of two series of lateral shocks and recorded whereby the amplitude and duration of transients are closely checked.

(b) Recording of the output from a ½" cathode follower loaded by a 20 pF dummy cartridge, exposed to a sound field of 130 dB at varying frequency.

frequency cut-off, cable length and harmonic distortion, showing the limiting values are given in Fig. 1.11.

The power supplies necessary to operate the cathode followers are provided by the amplifier or the Microphone Power Supply Type 2801 via the multi-pin-socket at the front panel as shown in Fig. 1.12.

The cathode followers can be used separately whenever a high input impedance amplifier is needed for voltage measurements at the output of small transducers etc. An input adaptor JJ 2614 is supplied for this purpose with each cathode follower, as seen in Fig. 1.7. The adaptor can be screwed onto the cathode follower housing instead of the microphone cartridge and contains a capacitor of a few thousand pF for blocking the 200 V DC polarization voltage. The adaptor provides a standard 14 mm coaxial socket fitting the B & K JP 0018 plug.

Technical Data.

Input Impedance: 700 MΩ in parallel with 3 ± o.5 pF.
(Below 10 Hz and above 2 Hz: more than 200 MΩ in parallel with 3 ± o.5 pF).

Output Impedance: Approximately 750 Ω. (The influence of a capacitive load is seen in Fig. 1.11).

Transmission Loss: Voltage gain = — o.9 dB ± o.2 dB. Total attenuation for a 20 pF Microphone Cartridge: 2.1 dB.

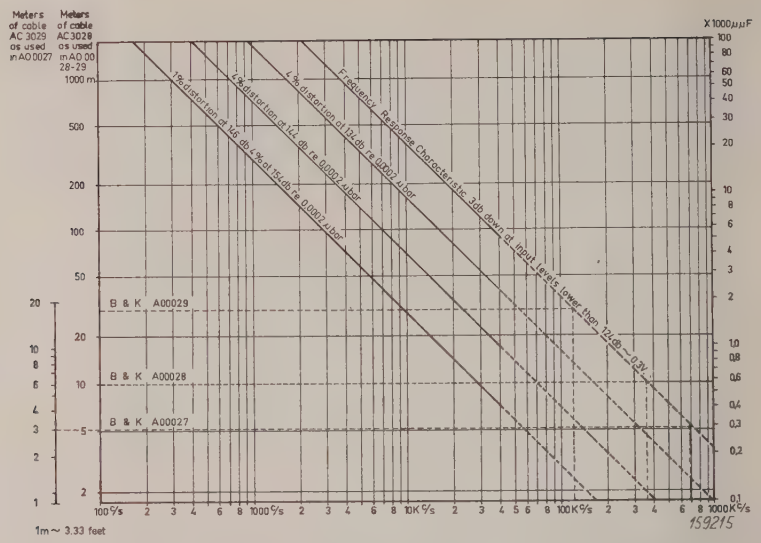

Meters of cable AC 3029 as used in AO 0027
Meters of cable AC 3028 as used in AO 00 28-29
X 1000 μμF
Frequency Response Characteristic 3db down at input levels lower than 12db re 0.02V
1% distortion at 12db re 0.0002 μbar
1% distortion at 12db re 0.0002 μbar
1% distortion at 16 db re 0.0002 μbar
B & K A00029
B & K A00028
B & K A00027
1m ~ 3.33 feet
159215

Fig. 1.11. Graph showing the performance of the 1/2″ microphones with different lengths of cables attached to the output.

Self-generated Noise Level: Approximately 40 μV at cathode follower output, with the input loaded by a capacitor of 20 pF (20 Hz—200 kHz).

Distortion: 4 % distortion occurs with input voltages higher than 20 volts RMS.

Tube: 5899 (EF731), specially tested for low microphonics.

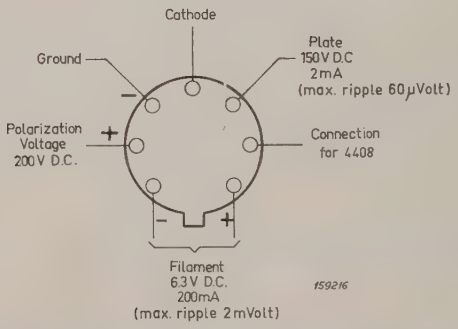


Fig. 1.12. Socket connections for the cathode followers (viewed from bottom). The negative pins are normally connected externally to ground.

General Characteristics (Cartridges + Cathode Followers).

1. Sensitivity. Frequency Response.

The sensitivity and the frequency response are individually measured for each cartridge by direct comparison to a standard microphone. Typical cartridge calibration charts are shown in Fig. 1.13. The sensitivity (at cathode follower output) of both microphones may be within 0.75—1.4 mV/μbar (— 62.5 and — 57 dB re 1 V/μbar). The normal incidence free-field response of Type 4133 + 2614/15 with protecting grid is constant within ± 2 dB from 20 Hz to 40 kHz and the random incidence or pressure response of Type 4134 + 2614/15 is constant within ± 2 dB from 20 Hz to 20 kHz. The free-field curves are derived from the pressure response curves recorded automatically by the electrostatic actuator method. (See "Microphone Calibration", in Appendix).

2. Free Field Corrections. The pressure increase which is caused by the reflections of free-field sound waves on the microphone diaphragm becomes appreciable above 2 kHz. The corresponding correction curves, which are valid for both cartridges are given in Fig. 1.14. The frequency response for the various angles of incidence is obtained by adding the free-field correction to the pressure response supplied with each cartridge. When mounting a Nose Cone on the microphones, however, the free-field corrections are practically independent of the angle of incidence. See Fig. 2.3.

The random incidence corrections, S, are calculated according to the formula given in the recommendations of the IEC for Sound Level Meters (IEC 123 § 8.2):

$S^2 = 0.018 \times S^2_0 + 0.129 \times S^2_{30} + 0.224 \times S^2_{60} + 0.258 \times S^2_{90} + 0.224 \times S^2_{120} + 0.129 \times S^2_{150} + 0.018 \times S^2_{180}$

$S_0, S_{30}, \ldots S_{180}$ = free-field corrections at the respective angles of incidence.

Fig. 1.15, or a comparison between Fig. 1.14a and b, shows that the protecting grid influence is important for free-field measurements. Since the microphones are calibrated with protecting grid, and because of the thinness of the diaphragm, the protecting grid should only be removed in very special circumstances such as coupler measurements, or measurements above 40 kHz.

3. Directional Characteristics. Since both types of cartridges have the same mechanical dimensions, their directional properties are identical. The curves shown in Fig. 1.16 can be considered as typical. However, small changes in the pattern above 40 kHz may be found from unit to unit due to very slight differences in the mechanical configuration.

Better omnidirectional properties can be obtained by mounting a Nose Cone UA 0052 instead of the protecting grid. See Fig. 2.4.

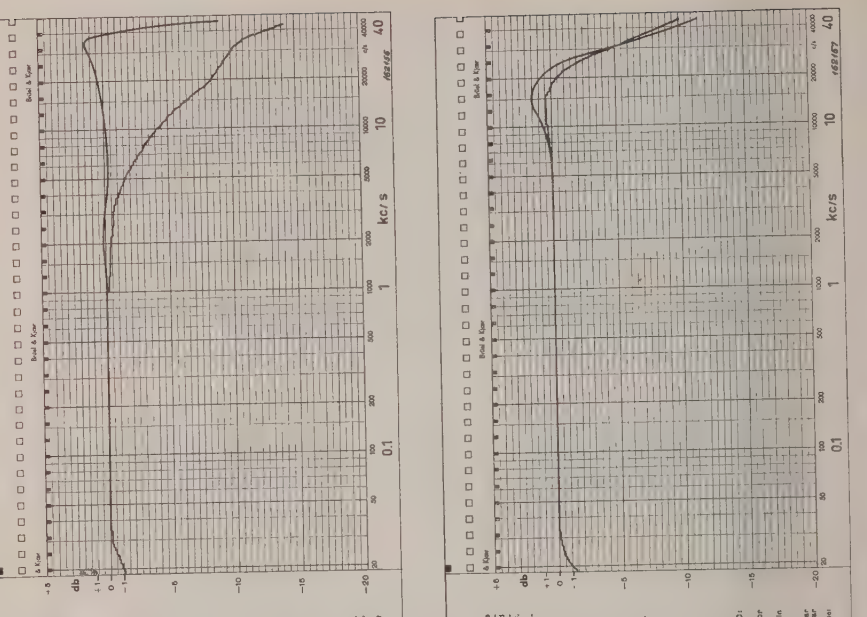

Calibration Chart for
Condenser Microphone
Cartridge Type 4133
Brüel & Kjær
Copenhagen
Serial No. 43000
Sensitivity at 250 c/s, 760 mm Hg, and with 200 V polarization voltage:
Measured at the output of a cathode-follower with input capacity 3 pF and gain 0.9 db (B & K Cathode-Follower Type 2615):
1.10 mV/µbar = −59.2 db re.1 V/µbar
Cartridge open circuit sensitivity
1.43 mV/µbar = −56.9 db re.1 V/µbar
Correction Factor, for direct sound level reading on B & K Instruments adjusted to 0 mV/µbar:
K = +13.2 db.
Cartridge Capacity at 1 kc/s with 200 V polarization:
17.4 pF.
Conditions of Test:
Temperature 23 °C
Barometric Pressure 770 mm Hg.
Relative Humidity 80 %
Date 12-10-61 Signature M.K.
Individual Frequency Response:
The upper curve is the free field characteristic, which is obtained by applying the correction factor to the sound pressure response measured on Cathode Follower 2614 and microphone mounted in accordance with the I.E.C. recommendations (See Fig.).
The lower curve is the pressure response curve recorded with electrostatic actuator.
Summarized Specifications
Outside Diameter: 0.5 Inch (12.7 mm), without protecting grid.
Grid Thread (coupler mounting): 0.5 Inch (12.7 mm) - 60 NS 2.
Resonant Frequency: approx. 25 kc/s (overdamped).
Equivalent Air Volume at 1 atm: approx. 0.01 cm³.
Temperature coefficient between −50 and +60°C: approx. −0.01 db/°C.
Ambient pressure coefficient: approx. −0.1 db for ±10% pressure change.
Relative Humidity influence: Less than 0.1 db, in the absence of condensation.
Dynamic Range:
Theoretical upper limit: 160 db re. 0.0002 µbar
174 db re. 0.0002 µbar
Safety limit:
B & K vs. db, two-way
Brüel & Kjær
db
+5
0
−5
−10
−15
−20
20
50
100
200
500
1000
2000
5000
10000
20000
c/s
40000
0.1
1
10
kc/s
40
4133/1
Calibration Chart for
Condenser Microphone
Cartridge Type 4134
Brüel & Kjær
Copenhagen
Serial No. 43001
Sensitivity at 250 c/s, 760 mm Hg, and with 200 V polarization voltage:
Measured at the output of a cathode-follower with input capacity 3 pF and gain 0.9 db (B & K Cathode-Follower Type 2615):
1.08 mV/µbar = −59.3 db re.1 V/µbar
Cartridge open circuit sensitivity:
1.37 mV/µbar = −57.2 db re.1 V/µbar
Correction Factor, for direct sound level reading on B & K Instruments adjusted to 0 mV/µbar:
K = +13.3 db.
Cartridge Capacity at 1 kc/s with 200 V polarization:
20.0 pF.
Equivalent Air Volume at 1 atm: 0.008 cm³.
Individual Frequency Response
Attached frequency response curve is valid for the Condenser Microphone Cartridge 4134, mounted on Cathode Follower 2614 or 2615, and was measured in a sound field in which the sound pressure is calculated in accordance to the I.E.C. recommendations.
The lower curve is the pressure response recorded with electrostatic actuator.
Conditions of Test:
Temperature 23 °C
Barometric Pressure 770 mm Hg.
Relative Humidity 80 %
Date 12-10-61 Signature M.K.
Summarized Specifications
Outside Diameter: 0.5 Inch (12.7 mm), without protecting grid.
Grid Thread (coupler mounting): 0.5 Inch (12.7 mm) - 60 NS 2.
Resonant Frequency: approx. 25 kc/s (critically damped).
Temperature coefficient between −50 and +60°C: approx. −0.01 db/°C.
Ambient pressure coefficient: approx. −0.1 db for ±10 % pressure change.
Relative Humidity influence: Less than 0.1 db, in the absence of condensation.
Dynamic Range:
Theoretical upper limit: 160 db re. 0.0002 µbar
174 db re. 0.0002 µbar
Safety limit:
B & K vs. db, two-way
Brüel & Kjær
db
+5
0
−5
−10
−15
−20
20
50
100
200
500
1000
2000
5000
10000
20000
c/s
40000
0.1
1
10
kc/s
40
4132/67

Fig. 1.13. Typical calibration charts such as supplied with each microphone cartridge. The error on the frequency response determination is less than 0.2 dB up to 10 kHz and 0.5 dB up to 40 kHz.

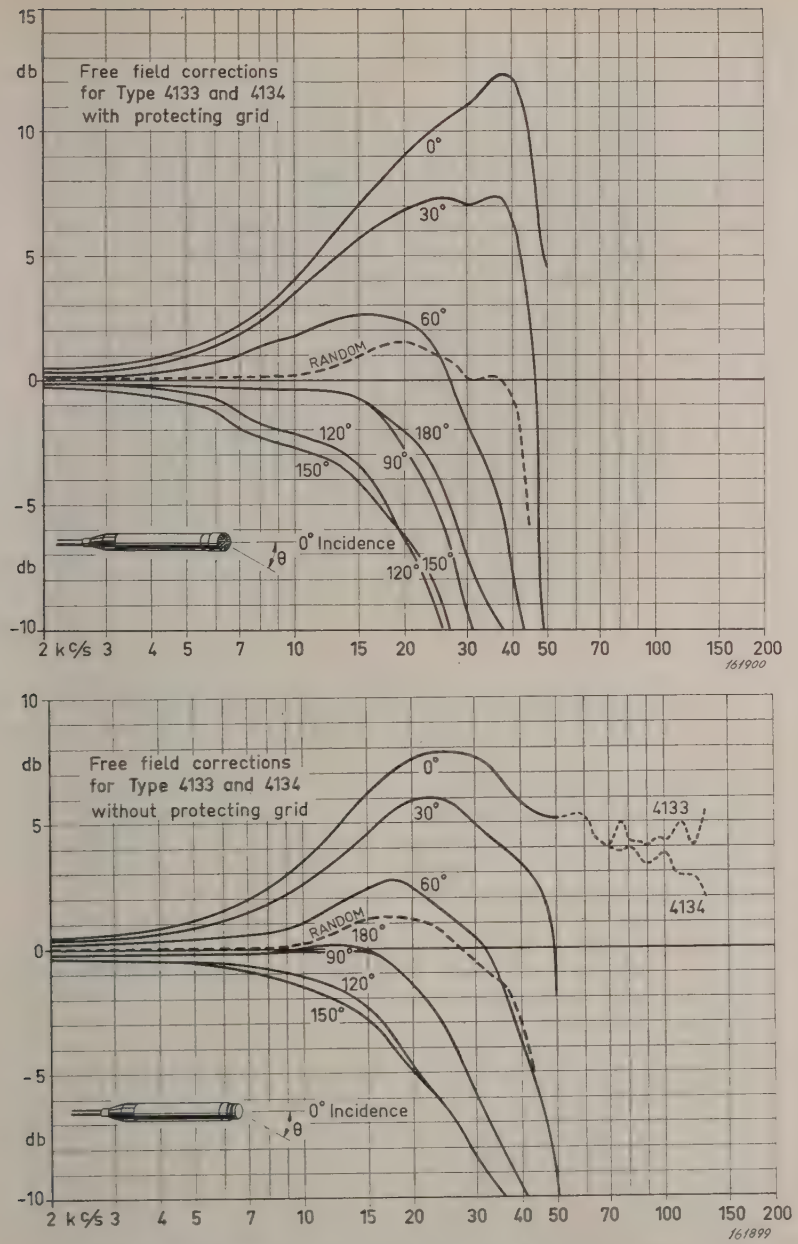


Fig. 1.14. Typical free-field correction curves to be added to the pressure characteristic of the half-inch microphones.

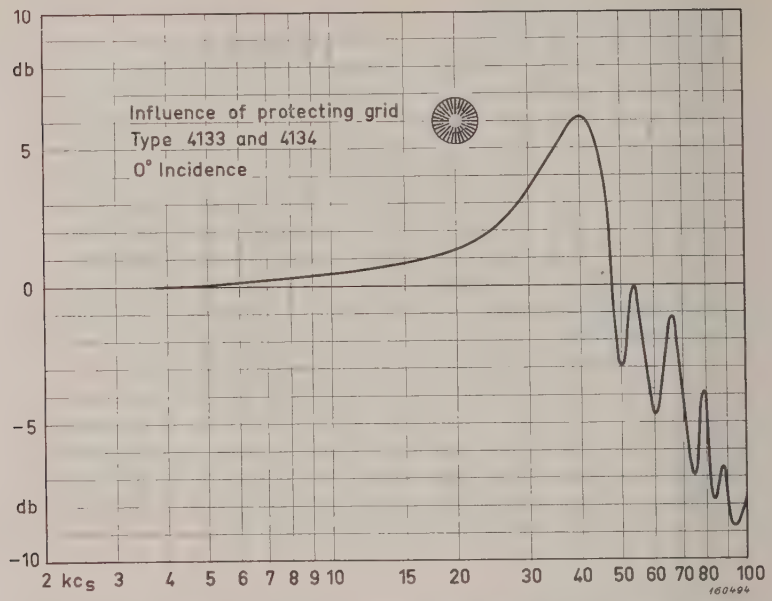


Fig. 1.15. The influence of the protecting grid upon the free-field response curve of the microphones. The grids are individually adjusted during manufacture in order to obtain this characteristic to within 0.2 dB up to 30 kHz 0.5 dB above.

4. Dynamic Range. Noise and Distortion. The lower limit of the dynamic range is set by the inherent noise level of the cathode follower. With a microphone cartridge, the sensitivity of which is 1 mV/μbar, this limit will be equal to a sound level of 32 dB with reference to 2×10^{-4} μbar when measured with a standard weighting network A.

The total noise level of the Cathode Followers Type 2614-2615 is approx. 40 μV (46 dB with reference to 2×10^{-4} μbar), measured with a capacitor of 20 pF across the input and in a bandwidth of approximately 200 kHz (20 Hz—200 kHz). When measured in third octave bands the noise level is less than 2 μV (20 dB with reference to 2×10^{-4} μbar) except at frequencies lower than 120 Hz where it is less than 7 μV (30 dB re 2×10^{-4} μbar).

The upper limit of the dynamic range is set by the harmonic distortion, and is above 160 dB for 4 % total harmonic distortion. See Fig. 1.17. The dB values given in the graph are valid when using a microphone with a sensitivity of 1 mV/μbar. Whenever the microphone sensitivity is lower, the limiting values will be correspondingly higher. Also, at frequencies that are above the resonance frequency of the microphone, the sensitivity will decrease, thus giving a raise to the distortion limits. See also Fig. 1.11.

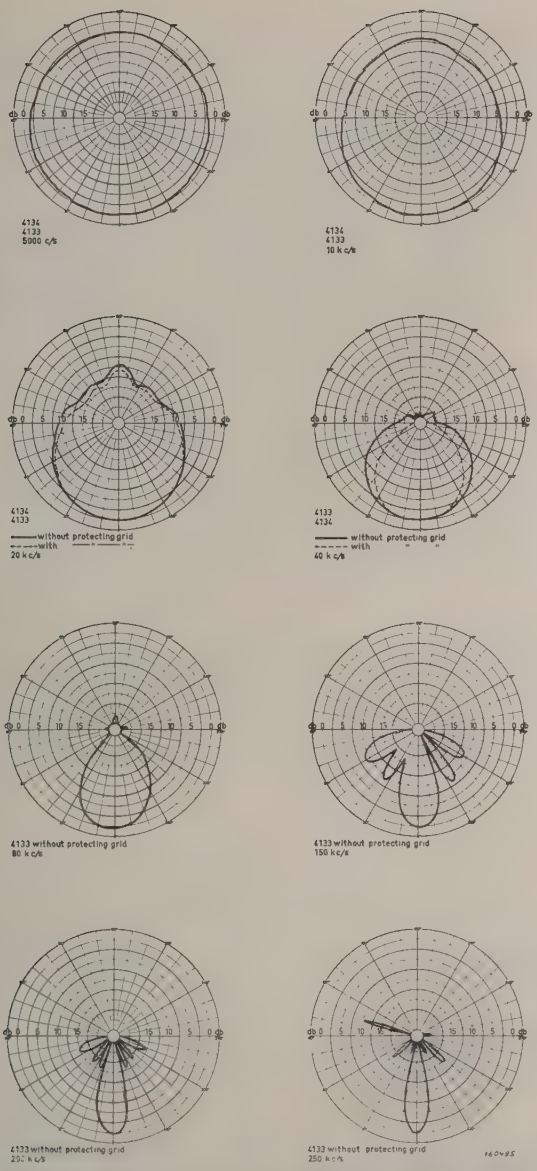


Fig. 1.16. Typical directional characteristics of the ½″ microphones.

If, for example, a cathode follower is used with the cable AO 0029 (length 30 m) and a microphone cartridge with a sensitivity of 1 mV/μbar is employed, the 4 % distortion limit is 144 dB at 20 kHz but as high as 160 dB

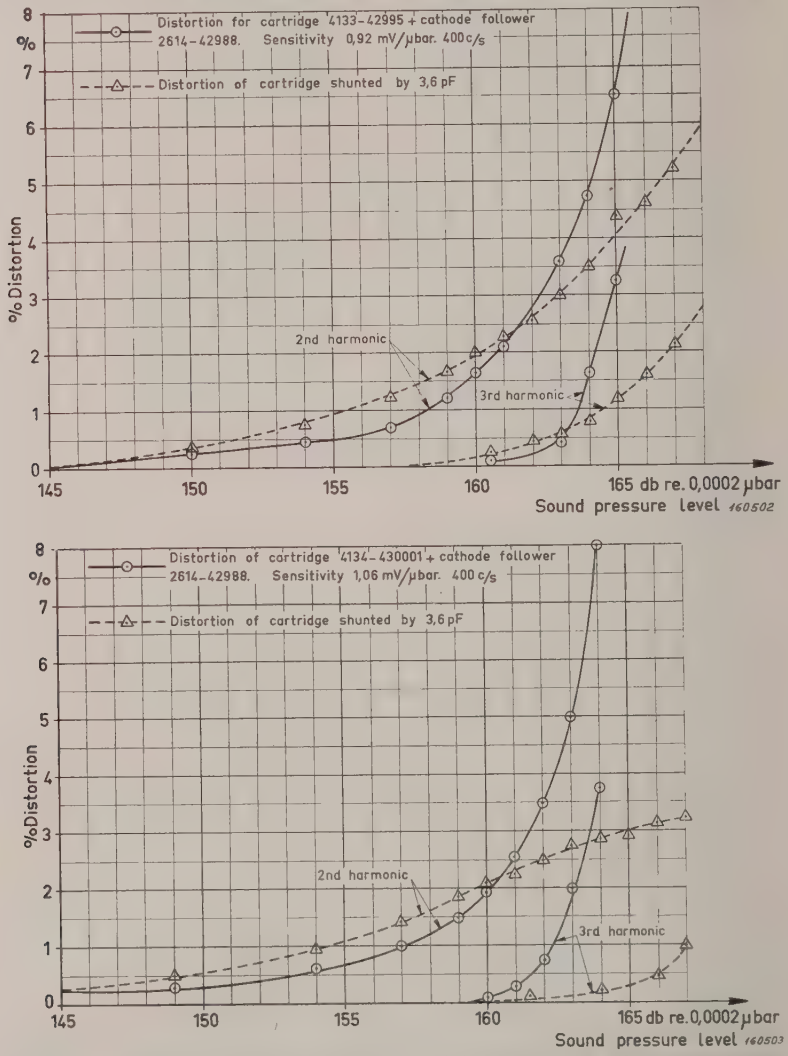

Distortion for cartridge 4133-42995 + cathode follower 2614-42988. Sensitivity 0,92 mV/μbar. 400 c/s
Distortion of cartridge shunted by 3,6 pF
% Distortion
2nd harmonic
3rd harmonic
165 db re. 0,0002 μbar
Sound pressure level 160502
Distortion of cartridge 4134-430001 + cathode follower 2614-42988. Sensitivity 1,06 mV/μbar. 400 c/s
Distortion of cartridge shunted by 3,6 pF
% Distortion
2nd harmonic
3rd harmonic
165 db re. 0,0002 μbar
Sound pressure level 160503

Fig. 1.17. Typical distortion curves for the ½" microphones. The curves drawn in full are relative to a complete microphone. Above: 4133, below: 4134.

at 100 kHz due to the decrease in sensitivity. Above 25 kHz the decrease in sensitivity will amount to 12 dB per octave, while the increase in distortion, due to the load of the cable, is only 6 dB per octave. No damage will be caused to the cartridge if exposed to a sound pressure level of up to 174 dB with reference to 2×10^{-4} μbar, but as this is the highest SPL at which the microphone has been tested it is not recommended to exceed this value.

5. Phase Characteristics and Pulse Response. The pressure response phase angle characteristics can be seen in Fig. 1.18. The resonant frequency (90° phase angle) is 25 kHz. At low frequencies, a small negative phase shift is to be expected because of the cathode follower. Some examples of pulse response are shown in the Appendix.

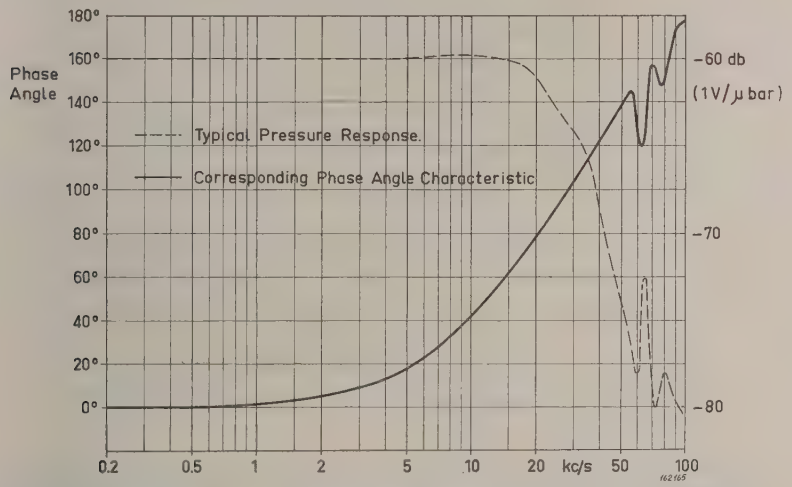


Fig. 1.18. Pressure response phase angle characteristic for Type 4134. Type 4133 has a slightly less change in phase angle at higher frequencies. The dotted line indicates the frequency response.

6. Equivalent Volume. The equivalent volume of the Microphone Cartridges Type 4133 and 4134 at 1000 Hz is approximately 0.010 cm^3.
When dealing with closed cavity measurements (coupler measurements) it is convenient to express the acoustical input impedance of a condenser microphone in terms of the acoustical impedance of an equivalent volume, V_e, by use of the equation

$$j\omega Z_a V_e = \gamma P_a$$

where γ = ratio of specific heats (1.41), P_a = ambient pressure, Z_a = acoustical impedance of the microphone, and ω = angular frequency.

When the Microphone Cartridge Type 4134 is used in coupler measurements it is necessary to know its equivalent volume. This quantity is therefore individually controlled on each 4134 cartridge during manufacture and is given in the calibration chart supplied with the cartridge. The value given is measured at 1000 Hz. The variations with frequency are shown in Fig. 1.19.

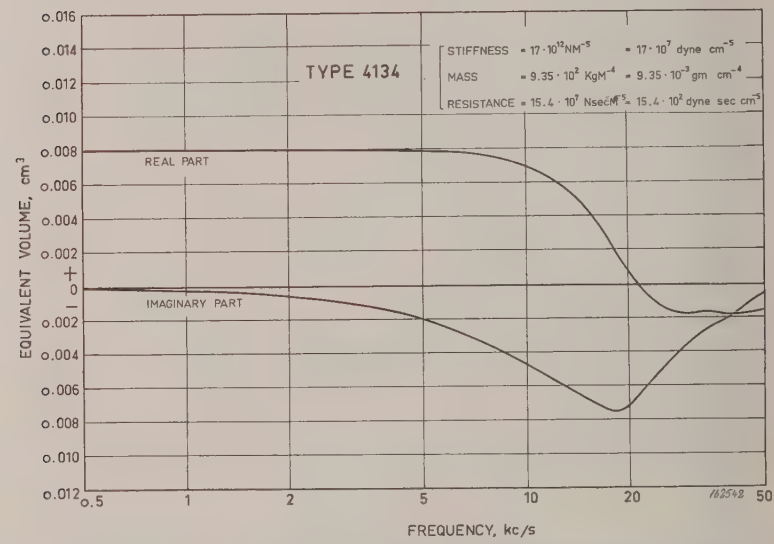


Fig. 1.19. Equivalent Volume and Lumped Acoustical Parameters for the 4134.

7. Polarized Cartridge Capacity.

Owing to the variation of diaphragm compliance the cartridge capacity is dependent on frequency as shown in Fig. 1.20 in a typical case. For the

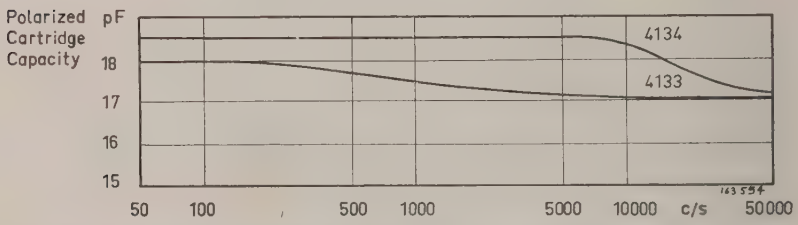


Fig. 1.20. Variation of the electrical capacity of the half-inch cartridges as a function of frequency.

particular value of a cartridge capacity at 1 kHz, see the individual calibration chart.

8. Influence of the Polarization Voltage.

The condenser microphone cartridges have been designed to operate with a polarization voltage of 200 volts. The polarization voltage, supplied from the instrument to which the condenser microphone is connected, should thus be adjusted to 200 volts before measurements are taken. Adjustment instructions will be found in the manual for the respective amplifiers.

If the Microphone Cartridges Type 4133 and 4134 are operated with polarization voltages differing from the above stated 200 volts (max. 250 volts) their sensitivity will change as shown in Fig. 1.21. Only a negligible change in frequency response will take place.

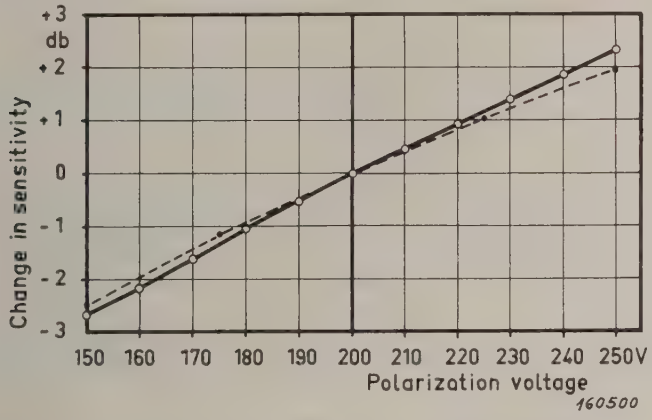
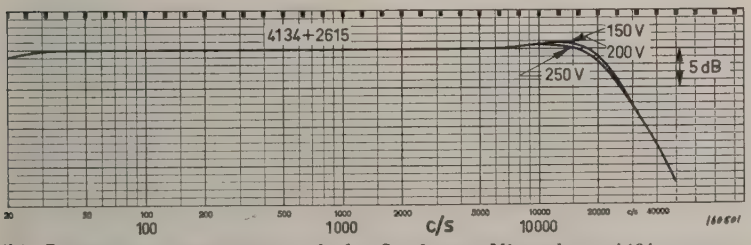


Fig. 1.21.
(a) The microphone sensitivity versus polarization voltage at a frequency of 1ooo Hz (fully drawn curve). The dotted curve gives the proportional value without taking the change in air gap into account.



(b) Pressure response curves of the Condenser Microphone 4134 measured at three different values of polarization voltage. The recorder was adjusted to give the same deflection at 1ooo Hz for all three curves.

9. Temperature Characteristics. Special care has been taken during the development and subsequent manufacture of the microphone cartridges to obtain a characteristic which, to a high degree, is independent of temperature. A typical temperature-sensitivity curve is shown in Fig. 1.22 together with a set of frequency curves at different temperatures, from which it is noticed that only a small decrease of about 2 dB is to be expected around the resonance frequency when measurements are carried out at up to 150°C (300°F).

The insulation material used in the connecting cables of the Cathode Follower 2615 should not be exposed to higher temperatures than 100°C

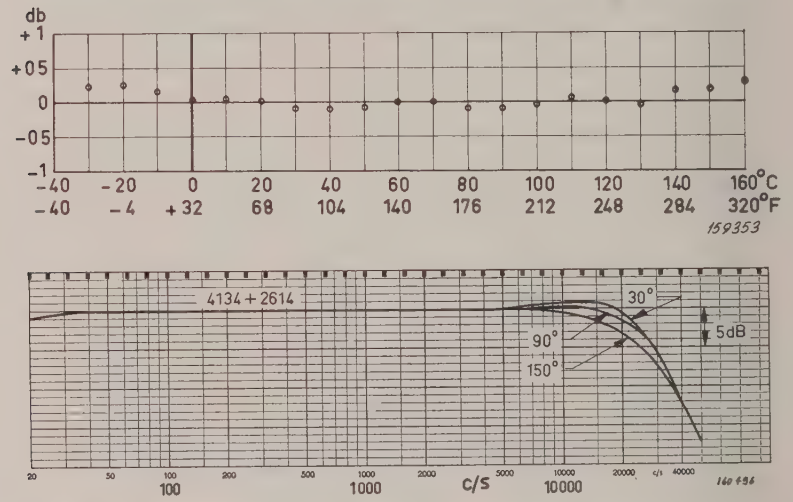


Fig. 1.22. Curves showing the microphone sensitivity's dependency upon temperature.
(a) Sensitivity at 400 Hz.
(b) Typical frequency response curves of Type 4134 at different temperatures.

(212°F). The Cathode Follower 2614 will be able to stand temperatures up to 150°C (300°F) on the housing or the goose neck. (250°C intermittently). The cartridges stand temperatures of up to 150°C (300°F) continously, and 250°C (480°F) intermittently (10 minutes maximum).

10. Influence of Ambient Pressure. The microphone sensitivity will vary approximately —1 % for +10 % variations in ambient pressure. For important changes in ambient pressure the frequency response of the microphone will be modified, especially towards the higher frequencies because of the change in mechanical damping. The frequency response at different ambient pressures is given in Figs. 1.23 and 1.24.

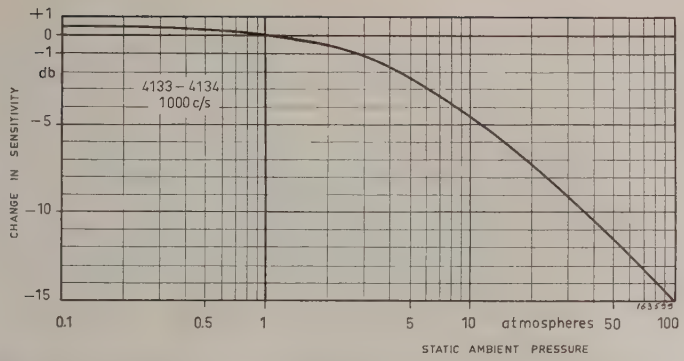


Fig. 1.23. Variation in microphone sensitivity as function of the ambient pressure.

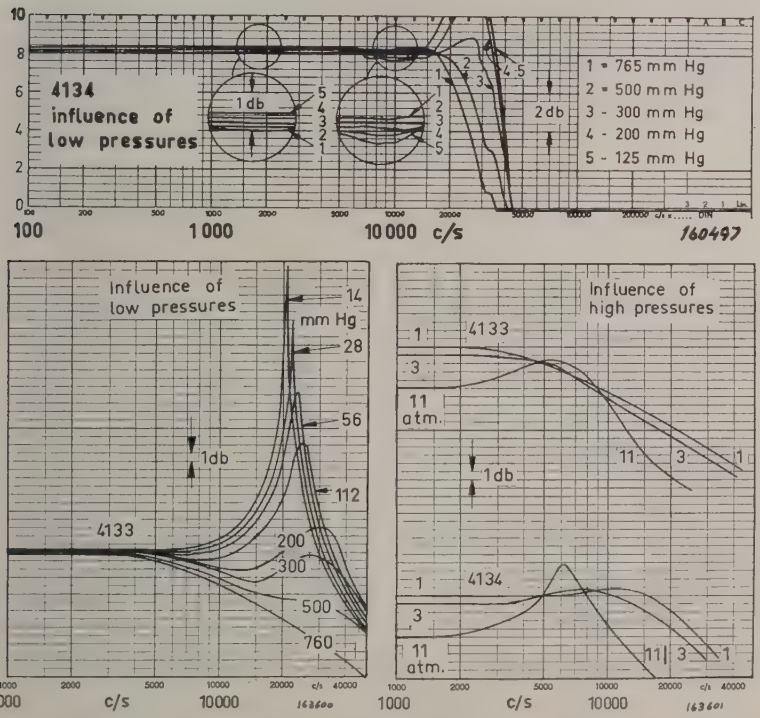


Fig. 1.24. Charts illustrating the influence of the ambient pressure on the frequency response. Below 200 mm Hg, the response of the 4134 is as shown for the 4133.

The ambient pressure may change approximately 10 % per second with less than 1 dB change in sensitivity. For a more detailed discussion of the performance under low pressure and varying altitude conditions, see B & K Technical Review No. 1-1960.

11. Influence of Vibrations. The influence of a vibration will depend on the direction in which it is applied to the microphone. When the force is acting in a direction which is parallel to the axis of symmetry (i.e. at right angles to the diaphragm) the sensitivity to vibration is mainly determined by the mass of the diaphragm and the air column on both sides of it. The microphone will be most sensitive to vibration acting in this direction, but due to the low diaphragm mass, the signal produced from vibrations having an

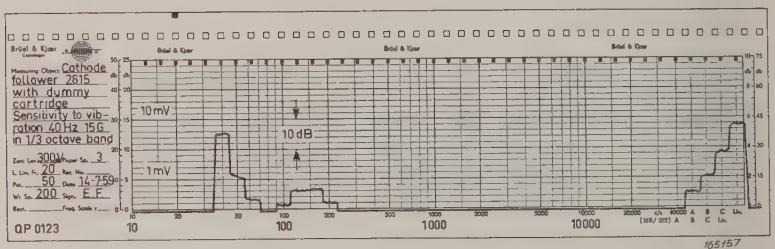


Fig. 1.25. 1/3 octave analysis of the output from a cathode follower which is subjected to a constant acceleration level of 15 G r.m.s. (40 Hz) perpendicular to the cathode-follower axis.

acceleration of 1 G is as low as an equivalent sound pressure level of 88 dB. The sensitivity to vibrations acting at right angles to the axis of symmetry (parallel to the diaphragm) is determined by the electrodes of the cathode follower tube.

In Fig. 1.25 is shown the spectrogram of the output signal from a cathode follower with dummy microphone when vibrated at 40 Hz 15 G.

In Fig. 1.26 is shown the sensitivity to vibrations of varying frequencies. The

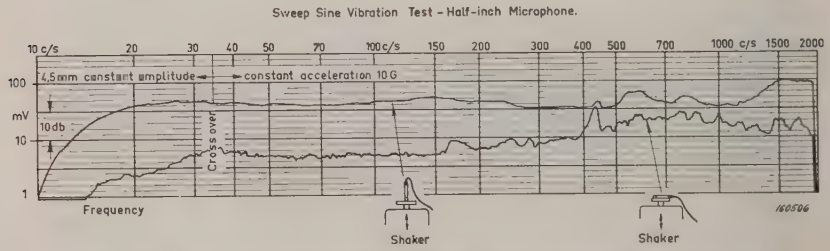


Fig.1.26. Output from a cathode follower and microphone subjected to a ***frequency sweep vibration test.***

curves cover the frequency range from 10 Hz to 2000 Hz. The slight increase towards the higher frequencies was due to the difficulty in maintaining the correct movements of the shaker table.

12. Sensitivity to Magnetic Fields. The sensitivity of the microphone to magnetic fields can be seen from Fig. 1.27. The output signal from the cathode follower was analyzed while the cartridge + cathode follower was exposed to a magnetic field having a strength of 50 gauss. The sensitivity to a 50 gauss field is found to be approximately 64 dB in terms of equivalent Sound Pressure Level. Although this sensitivity is very low, the influence from magnetic fields may be completely eliminated by screening the cartridge + cathode follower with a 2″ long ⅝″ diameter iron tube.

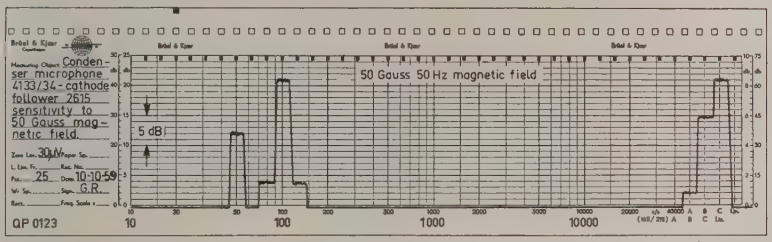


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Fig. 1.27. Spectrogram of the output signal when the microphone is exposed to a magnetic field of 50 gauss, 50 Hz with the most unfavorable orientation.

13. Influence of Humidity. Large variations of ambient temperature may in some cases cause moisture condensation to take place between the diaphragm and the electrode of the cartridges. There is then a temporary risk of electrical noise and cracking. However, due to the heat generated by the cathode follower, the condensed water will evaporate within a few minutes through the pressure equalization tube. A complete description of these phenomena will be found in the B & K Technical Review No. 1-1960, p. 12—15.

In the absence of condensation, the relative humidity percentage has practically no influence on the microphone sensitivity.

For permanent exposure outside, a Rain Cover Type UA 0056 should be used. (See Accessories).

2. Accessories

Nose Cone UA 0052.

The Nose Cone UA 0052 is designed to substitute the protection grid of the Cartridge Type 4133. The Nose Cone is extremely useful for measurements in wind tunnels, ducts and in other locations where the microphone is subjected to high speed airflows as well as for many out-of-door applications, where wind disturbance is likely to occur. In addition, a microphone, when used with the Nose Cone, has omnidirectional properties which are often of advantage for indoor uses.

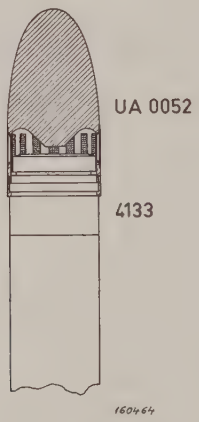

Fig. 2.1. Sectional drawing of the Nose Cone UA 0052.

The construction of the Nose Cone is clearly seen from the sectional drawing in Fig. 2.1. It is shaped to give the least turbulences to air flows. The fine wire mesh around the circumference allows sound waves to penetrate to the microphone diaphragm, while the truncated cone inside the mesh reduces the air volume in front of the diaphragm.

The reduction of wind noise which is obtainable with a Nose Cone is of the order of 10 dB with B & K microphones. It is described in detail in the B & K Technical Review No. 2-1960.

In addition to wind noise reduction, the Nose Cone provides excellent mechanical protection and improves the omnidirectivity of the microphone as shown in the following figures.

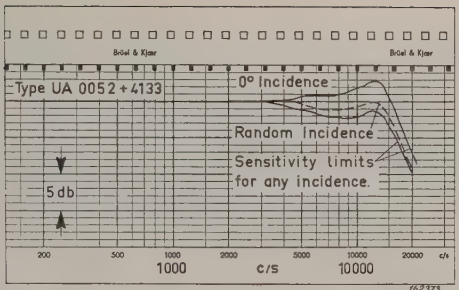

Fig. 2.2. Free-field response of a ½″ microphone equipped with nose cone. The omnidirectivity and linearity are effective within ± 3 dB up to 15 kHz.

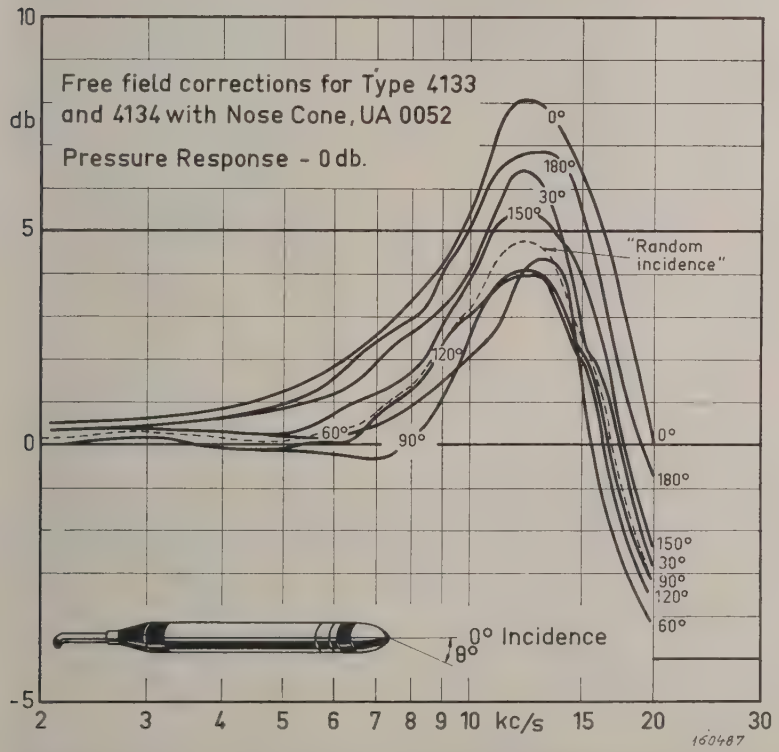

Fig. 2.3. Free field corrections for the microphones with the nose cone applied.

By examining Fig. 2.3, which shows the free field response correction curves for various angles of incidence, and then comparing these figures with Fig. 1.14 showing the free field corrections with the normal protection grid, it can be seen that the Nose Cone gives the microphone a more omnidirectional characteristic at high frequencies. A similar result may also be observed by comparing the directional characteristics shown in Fig. 1.16 and in Fig. 2.4, the latter giving the directional properties of the microphone with Nose Cone.

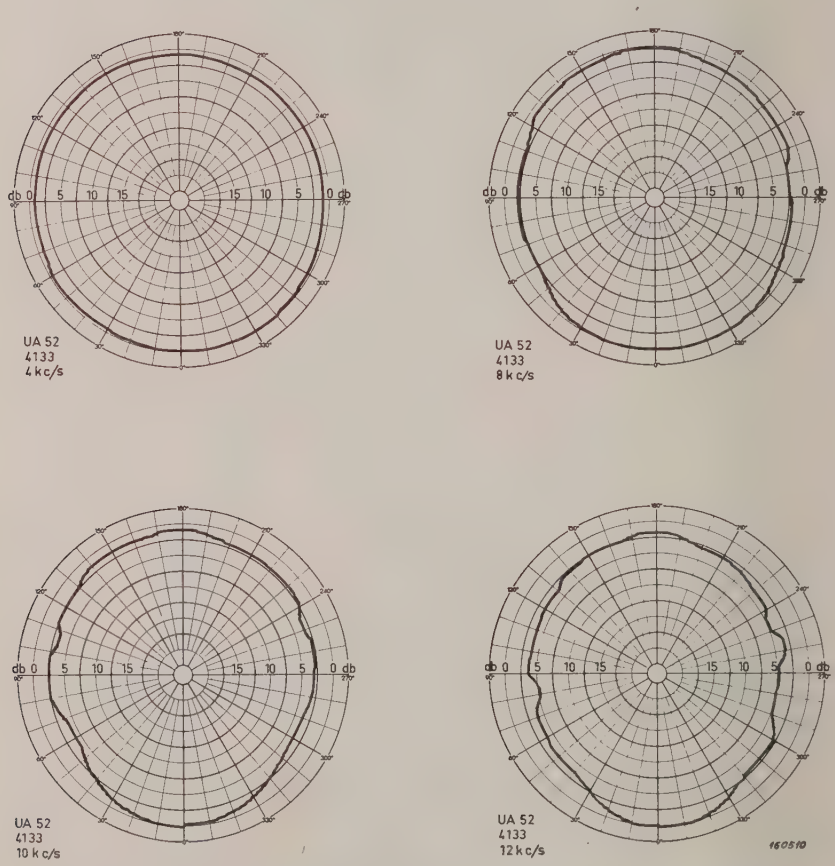

Fig. 2.4. Directional characteristics of the microphone Type 4133 + 2614/15 with nose cone UA0052.

Rain Cover UA 0056.

This accessory has been designed in order to allow permanent outdoor installation of the microphones, e.g. on airfields, even under extreme weather conditions. With a view to reducing the maintenance to a minimum, an electrostatic actuator is built into the rain cover, allowing remote controlled calibration and check of the installations to be made. When the associated 4133 cartridge is ordered together with the UA 0056, the actuator is adjusted at the factory so as to obtain an equivalent SPL of 90 dB ± 1 dB by injection of an AC voltage of 215 V (or 80 dB at 120 V).

The B & K screened cables AO 0037 or AO 0038 (not included) fit the actuator terminal.

The maximum working temperature of 4133 + UA 0056 is 150° C.

NB. The microphone is only fully protected when the associated cathode follower Type 2614/15 is permanently heated.

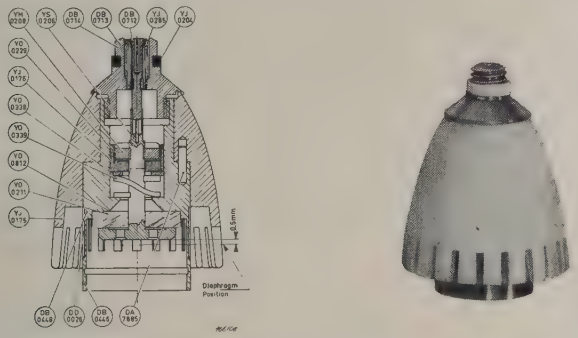

Fig. 2.5. The Rain Cover UA 0056 with cable connector for feeding the built-in calibrator.

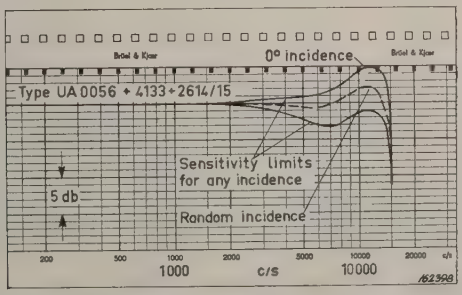

Fig. 2.6. Response of a half-inch microphone (Type 4133 + 2615) provided with a Rain Cover UA 0056. The increase in sensitivity at high frequencies may easily be compensated for by appropriate loading of the microphone output.

Probe Microphone Kit UA 0040.

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Mounting 38
Measurement of Tubes Walls Transmission 39
Calibration and Damping Adjustment of the Probes 41
Recording of the Frequency Response 42

Purpose and Principle.

Probe microphones can be used for a variety of applications such as measurements in the ear, measurement of sound insulating material and within intricate machinery, as well as in other inaccessible places, e.g. small ducts, furnaces, oilburners, etc.

The requirements for length and width of the probes will vary with the application, but to obtain the best possible frequency characteristics, it is advisable to use a tube that is as short and wide as possible.

The probes have been compiled as a kit which allows the best possible choice of tube diameter and length for any particular application to be made.

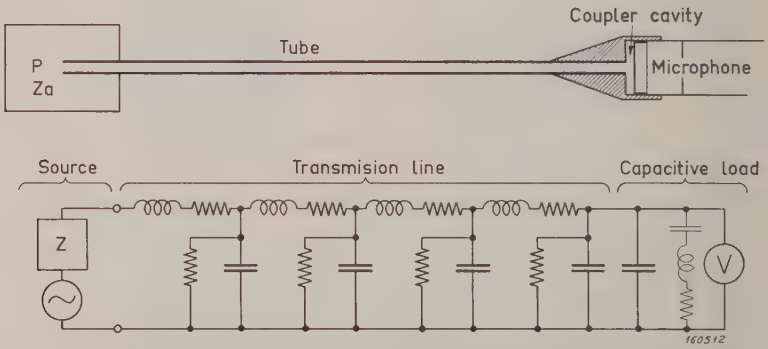


Fig. 2.7. The probe microphone with equivalent electrical diagram.

As mentioned above, the performance of a probe microphone depends on the length and the width of the tube. Also the acoustical impedance of the microphone cartridge (equivalent volume of the cartridge) and the volume between the microphone diaphragm and the end of the tube terminating this volume, play an important role. The tube diameter is normally very small compared to the wave length, but the length of the tube will be the same or several times larger than the wavelength for a great portion of the audio-frequency range.

The response for a certain probe microphone will be determined by the attenuation of the tube given by:

$$\beta = K \frac{\sqrt{\omega} \times l}{d}$$

where K = a constant (see Beranek: "Acoustical Measurements", page 188)
ω = angular frequency
l = tube length
d = tube diameter.

Furthermore, the ratio between the characteristic impedance of the tube and the impedance of the acoustical capacitor terminating the microphone end of the probe will change with frequency and cause a change in response. See Fig. 2.7. Variations in frequency response may thus be expected for different tube dimensions.

1. Linear response for low source impedance, low transmission loss and high impedance of the load as may be experienced for very short and wide tubes at low frequencies.
2. A 3 dB/octave drop in sensitivity at higher frequencies caused by transmission losses with medium size and length of tubes.
3. A 6 dB/octave drop in sensitivity at higher frequencies caused by the load of the capacitive coupler volume across the resistive part of the tube impedance with long narrow tubes (Fig. 2.8).
4. A 9 dB/octave drop in sensitivity at higher frequencies caused by a combination of 2 and 3, especially at high frequencies (Fig. 2.6).
5. A more or less pronounced resonance caused by the mass reactance of the tube in connection with the coupler cavity acting as a Helmholtz resonator with very short and wide tubes and large coupler cavities.

For tubes with o.6 mm inside diameter (as for the 1 mm tube) or more resonances will appear when the length of the tube is equal to ¼ — ¾ — 5/4 — 7/4 ... wavelengths, see Fig. 2.9. This condition is caused by a combination between the input impedance and the impedance of the tube with its termination. It is possible to obtain a smoother response by introducing

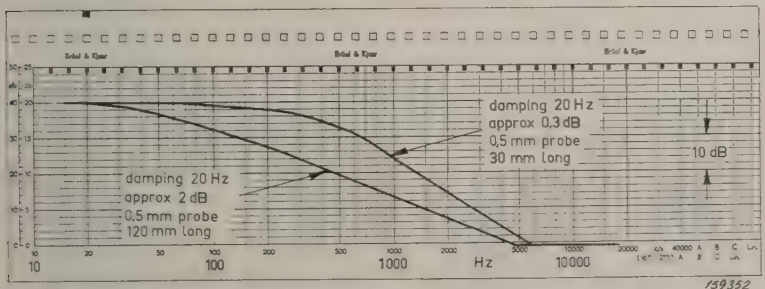


Fig. 2.8. Typical frequency response curves for a narrow probe microphone. (The recorder was adjusted to give the same deflection at 20 Hz in both cases).

damping material at the ends of the tube. In practice it is often sufficient to use damping of the front end only. It is then possible to adjust the damping in such a way that undulations on the frequency response are avoided at the low or high frequency end of the frequency characteristic, while some smaller undulations will show up over a limited range. (Fig. 2.14).

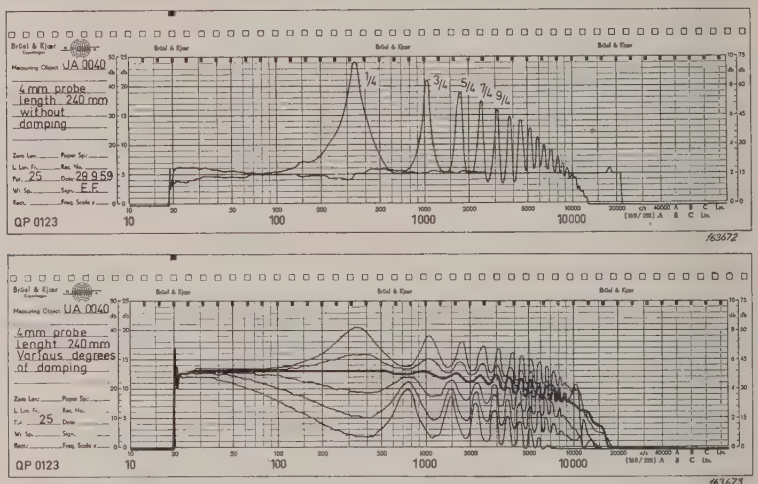


Fig. 2.9. Recording showing the resonance modes of a probe microphone.
(a) Undamped probe.
(b) Various degrees of damping (the lower curves indicate too heavy damping).

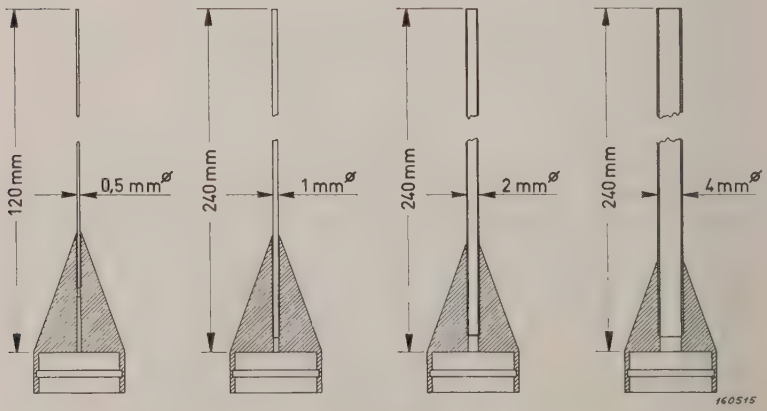


Fig. 2.10. Sectional drawing of the probe tubes.

Description of the Probe Kit UA 0040.

The Probe Microphone Kit Type UA0040 contains a set of four probe tubes with adaptors and tightening gaskets for mounting on the B & K ½″ microphones. Additionally, the set is provided with the accessories necessary for calibration and adjustment of the probe damping in connection with the B & K Response Recorders and Microphone Amplifiers, and the necessary tools for cutting the probes.

The construction of the probes can be seen from Figs. 2.10 and 2.11. The probe tubes are made from stainless steel and pressed into a conical adaptor.

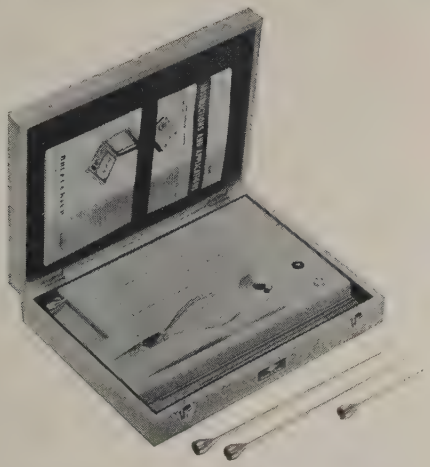


Fig. 2.11. Probe Microphone Kit Type UA 0040.

Part list	*Part Number*
1 0.5 mm Ø probe	DB 0240
1 1 mm Ø probe	DB 0241
1 2 mm Ø probe	DB 0242
1 4 mm Ø probe	DB 0243
1 spare tube for 0.5 mm Ø probe	YA 0051
1 spare tube for 1 mm Ø probe	YA 0052
1 spare tube for 2 mm Ø probe	YA 0053
1 spare tube for 4 mm Ø probe	YA 0054
4 teflon gaskets	YJ 0070
1 calibration coupler	DB 0260
1 earphone with plugs	HT 0003
1 PVC earphone adaptor	YJ 0084
1 mechanical adaptor for mounting ½″ cartridge as exciter	DB 0225
1 dummy microphone consisting of DB 0262 screwed into	DB 0264

1 special tong ..... QA 0022
1 file ..... QA 0017
Some steel wool No. 0 and emery paper No. 320

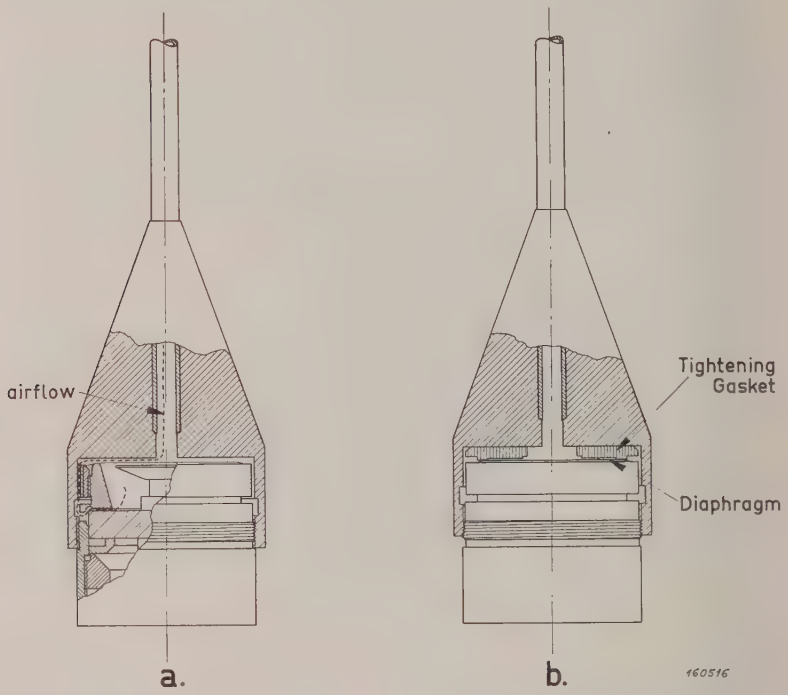


Fig. 2.12. Probe tubes mounted on microphone.
(a) Utilizing the equalization circuit.
(b) Mounted with gasket.

Mounting.

The mounting on the microphone may be carried out in two ways, either with or without the tightening gasket, as shown in Fig. 2.12a and b. When mounted without the gasket as shown in Fig. 2.12a, the probe adaptor is screwed carefully onto the microphone thread until the lower edge of the adaptor hits the collar on the microphone cartridge. This will ensure a distance from the diaphragm to the end of the probe tube of approximately 0.3 mm.

As shown in the figure, the pressure equalizing circuit of the microphone is utilized in this case. This means that a change in static pressure in the probe

tube will be transferred to the cavity behind the diaphragm, i.e. equalizing the pressure on both sides of the diaphragm.

When mounted with the tightening gasket as shown in Fig. 2.12b all dust should first be carefully removed from the microphone diaphragm and the gasket.

Note: The diaphragm has a thickness of only 0.004 mm and should only be lightly touched with a piece of cotton or other very soft material, and any cleaning must be carried out with extreme care. The gasket is then laid into the adaptor with the raised edge against the microphone. The cartridge is screwed into the adaptor until the gasket just touches the diaphragm and *only slightly tightened.*

Mounted in this way the pressure equalizing circuit is not utilized, while the air volume of the cavity in front of the diaphragm is considerably reduced. The air volume plus the equivalent volume of the microphone will in this case be lower than 0.02 cm^3 and thus ensures maximum performance with respect to frequency linearity, of the probe microphone.

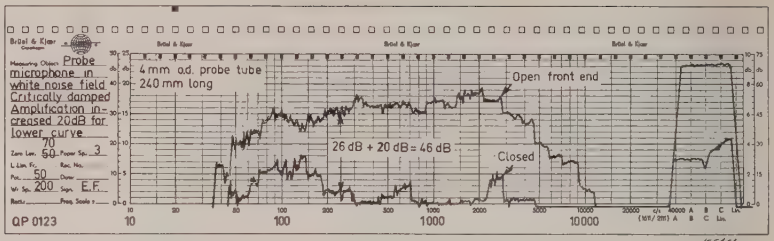
The reduction of the air volume has an increasing effect on the frequency of the probe tube resonance. The frequency of the fundamental resonance, may for the thinner tubes be increased as much as one octave, extending the linear portion of the response curve.

Measurement of Tubes Walls Transmission.

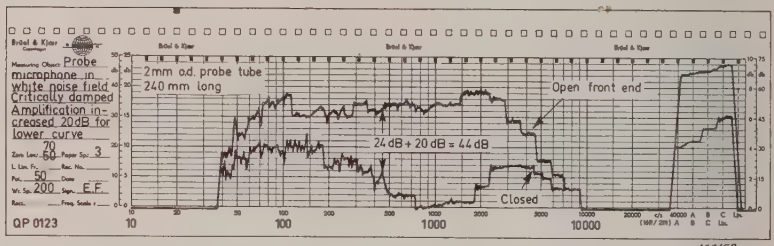
A probe microphone must, to measure correctly, be more sensitive to sound pressure at the tube input than it is to sound transmission through the side walls due to nonridgidity of the tube or leaks in the adapting piece to the microphone diaphragm. This property must be known for some applications, as for example, the measurement of the damping effect of ear cushions, where the sound pressure is measured outside and inside the ear cushion in order to determine the effect of the cushion itself.

The measurement of the probe microphones is easily carried out, by measuring the difference in output from the probe microphone, when placed in a sound field with and without the tube input being blocked.

In Fig. 2.13 is shown the ratio as obtained in third octave bands when the complete microphone is exposed to a sound field consisting of white noise. The upper curves indicate the sensitivity with open probe tube end, while the lower curves indicate the sensitivity with the end of the probe tube closed. The amplification of the measuring equipment was increased by 20 dB when the lower curve was taken, with a view to improving legibility (except for the 0.5 mm tube). It is therefore necessary to add 20 dB to read off the difference in sensitivity. The curves are obtained with a probe of full length which is well damped. For shorter tube lengths the performance will be the same or better.



a



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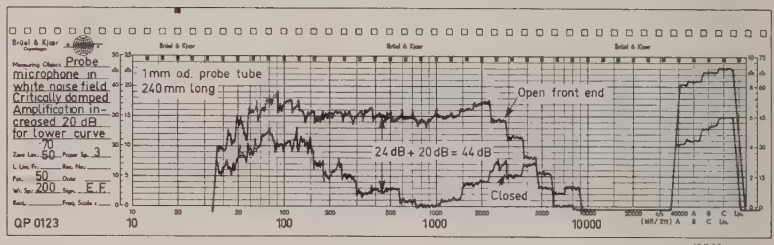

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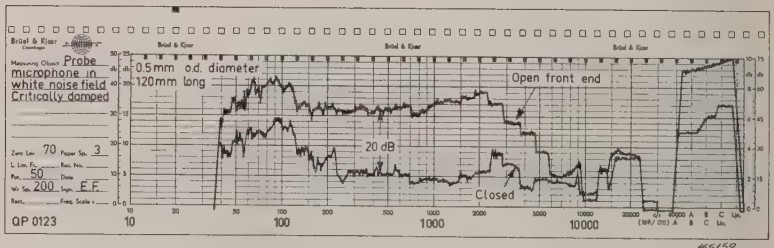


d

Fig. 2.13. Ratio of sensitivity of the probe microphones with open and closed tubes, as a function of frequency.
(a) 4 mm probe tube *(b) 2 mm probe tube*
(c) 1 mm probe tube *(d) 0.5 mm probe tube*

Calibration and Damping Adjustment of the Probes.

Calibration consists of the determination, at all frequencies of interest, of the change in microphone sensitivity due to the introduction of the probe, that is to say, of the frequency response of the probe. Accurate determination of this frequency response is easiest by the closed coupler technique as described below. A special 2 cm^3 coupler is supplied with the kit for this purpose. However, this calibration will be valuable for use in free-field, only if the acoustic impedance of the probe microphone is much greater than the acoustic impedance of the 2 cm^3 coupler. This condition may be verified by measuring the change in sound pressure in the coupler cavity with the probe microphone introduced, and with the hole in the coupler closed by e.g. a finger instead of the probe microphone. If more than say 3 dB variation is noted it is necessary to make the calibration in a larger coupler, or in free-field.

Free-field calibration is carried out by measuring the response in front of a suitable sound source, e.g. the Artificial Voice Type 4216 or for lower frequencies the small telephone incorporated in the probe kit, with the condenser microphone alone and with the probe microphone exactly at the same point. The distance from the sound source should be at least 5 cm (2″), and the incidence should be 90° (i.e. sound waves propagation perpendicular to the axis of the microphone in both cases).

The probes should be correctly "damped" in order to obtain the best possible frequency response as shown in Fig. 2.14. (The 0.5 mm diameter tube needs no extra damping as seen in Fig. 2.8).

The damping is obtained by means of the damping material supplied with the probe kit. The material is fine steel wool of a normal commercial quality, which is found suitable for the purpose.

To carry out damping, make a small oblong tuft of steel wool, not too firmly compressed, and insert in such a manner that the tube is filled out as

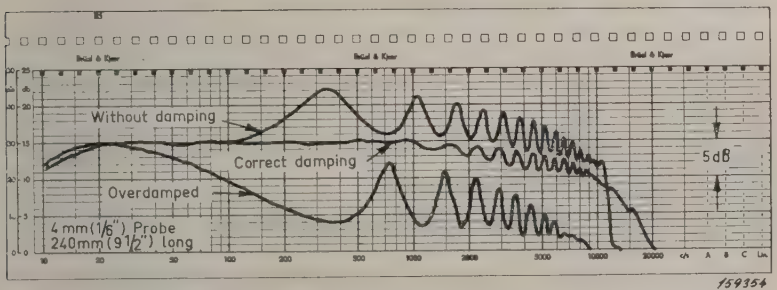


Fig. 2.14. Example of a frequency response for a probe microphone with different degrees of damping.

shown in Fig. 2.15. The smaller tubes may be used for the insertion of the damping material. For the 1 mm tube it may also be convenient to use a small piece of the 0.5 mm tube for the damping.
The degree of damping will mainly depend on the compactness of the filling. The aspect of the frequency response curve may be readily recorded by means of the arrangement of Fig. 2.16, and by a trial and error method an almost linear characteristic can be obtained over a wide frequency range, depending on the probe dimensions.

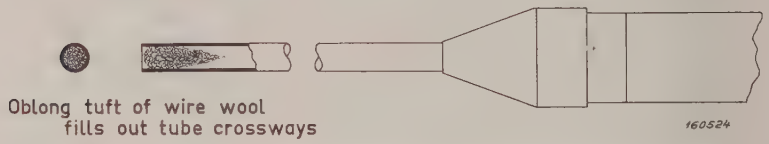


Fig. 2.15. Damping by means of wire wool applied in the probe tube.

Automatic Recording of Probe Microphone Frequency Response.
Figs. 2.16 and 2.17 show a suitable recording set-up consisting of an Automatic Frequency Response Recorder Type 3308 (B.F.O. Type 1022 + Level Recorder Type 2305), a Microphone Amplifier Type 2604,*), and the coupler and sound source as supplied with the probe kit. The sound source supplied with the Kit consists of a small earphone such as those normally used with hearing aids which is suitable up to 5 kHz. As shown in Figs. 2.19—2.22 this can be replaced by a Microphone Cartridge for calibration at higher frequencies. A sectional drawing of the coupler, with a probe tube and earphone inserted, is shown in Fig. 2.16. The probe tube should be inserted in such a manner that the end of the tube reaches the axis of symmetry of the coupler. Opposite to the earphone is shown a dummy microphone which should be inserted during the first part of the measurement, when no regulating microphone is employed.
The earphone is connected to the attenuator output of the B.F.O. 1022 (max. voltage to be applied: 1 V), while the microphone mounted on the probe tube via a Microphone Amplifier 2604 is connected to the Level Recorder 2305. By means of a chain drive the B.F.O. is mechanically connected to the Level Recorder whereby the paper drive of the Level Recorder can be synchronized with the rotation of the B.F.O. tuning condenser. In this manner the frequency response curves for the probe microphones can be automatically recorded.
The arrangement should be used after the probe tubes have been cut to the desired length to obtain several frequency response curves while damping the probe tube until a curve of suitable linearity is obtained.
While the arrangement of Fig. 2.16 is suitable for automatic recording of the sound pressure level at the output of the probe, the arrangement shown in

*) The Amplifier Type 2604 may be substituted by Type 2603.

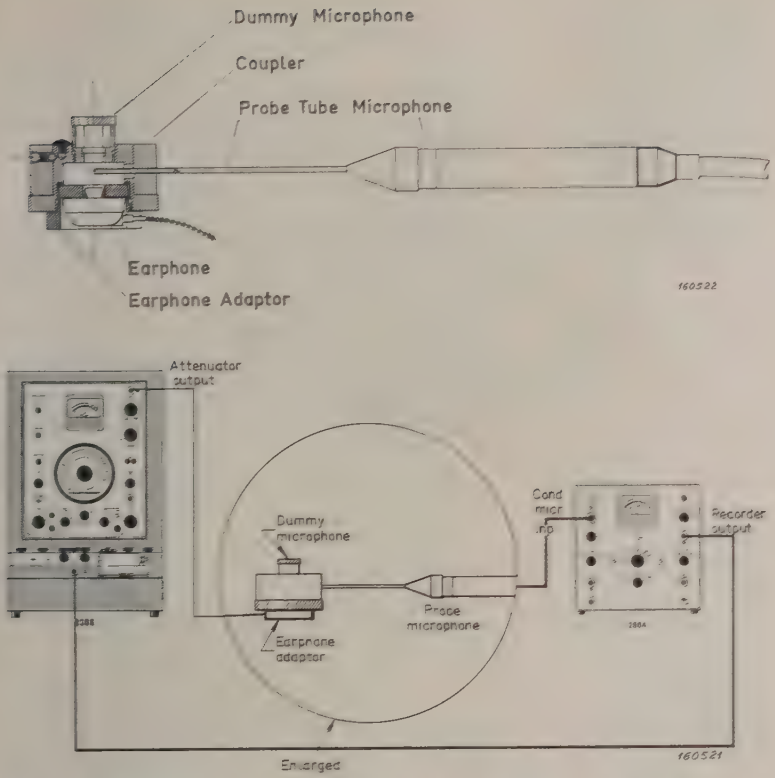


Fig. 2.16. Arrangement for the calibration of the probe tubes, with the aid of ***the coupler and earphone supplied.***

Fig. 2.17 gives a recording of the sound pressure level in the coupler. By subtracting one curve from the other, the damping characteristic for the probe tube is obtained directly in dB.

Instead of giving the probe tube damping as the difference between two curves, the set-up of Fig. 2.18 will enable a curve to be obtained, which immediately shows the probe tube damping in relation to a straight reference line. An example is seen in Fig. 2.9a.

The basic principle of this measuring method is the same as that employed in the arrangement shown in Fig. 2.16 except that in Fig. 2.18 a regulating microphone and amplifier is added. This microphone is connected via the amplifier to the compressor circuit of the B F.O. Type 1022, and allows a constant sound pressure level to be kept in the coupler.

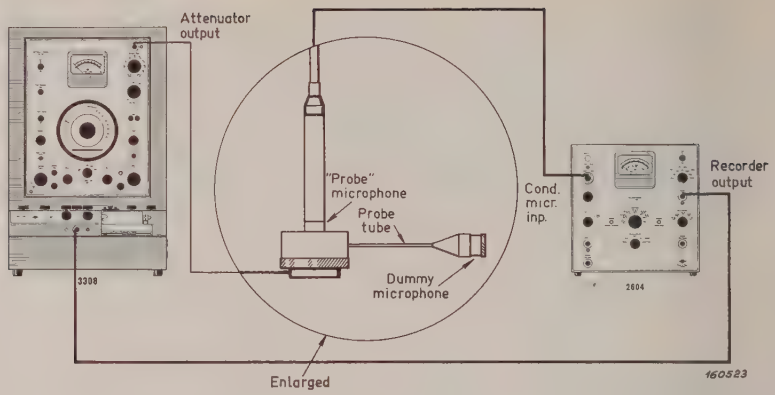


Fig. 2.17. Second stage of the calibration.

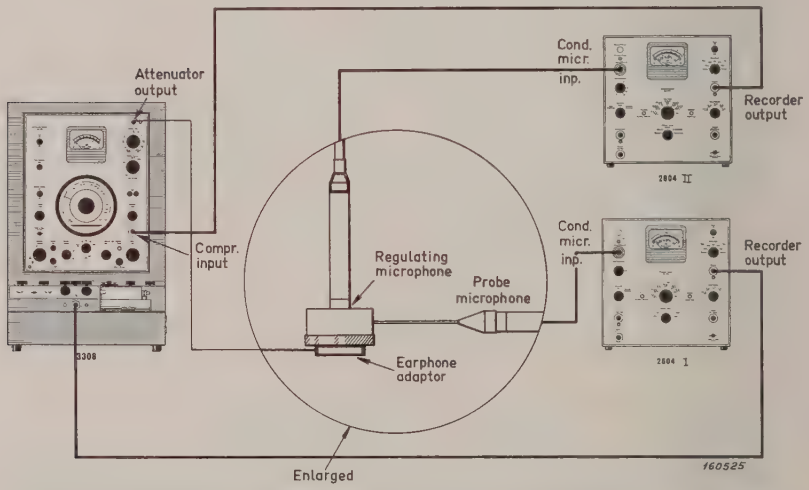


Fig. 2.18. Calibration arrangement with automatic regulation of the sound pressure in the coupler.

Use of a Microphone Cartridge as a Sound Source.

As mentioned above the earphone may be replaced by a condenser microphone cartridge used as transmitter. Both the "one-inch" and "half-inch" B & K cartridges may be mounted in place of the earphone adaptor, the supplied adaptor DB0225 being used in the case of the half-inch cartridge. The advantage of using a cartridge as exciter is mainly the obtainment of a more extended frequency range. Pressure calibrated cartridges Types 4132 and 4134 are therefore preferred, the linear range going up to 7 kHz with Type 4132 and to 20 kHz with Type 4134. As the sound pressure level in the coupler

is not necessarily constant for varying frequencies, although the sound source has a linear response, it is also advantageous to use a regulating circuit in this case.

The B & K Microphone Calibration Apparatus Type 4142 provides all facilities for mounting and connection of an exciting cartridge, and it should be used when available, as shown in Figs. 2.19 and 2.20. If not, the cartridge should

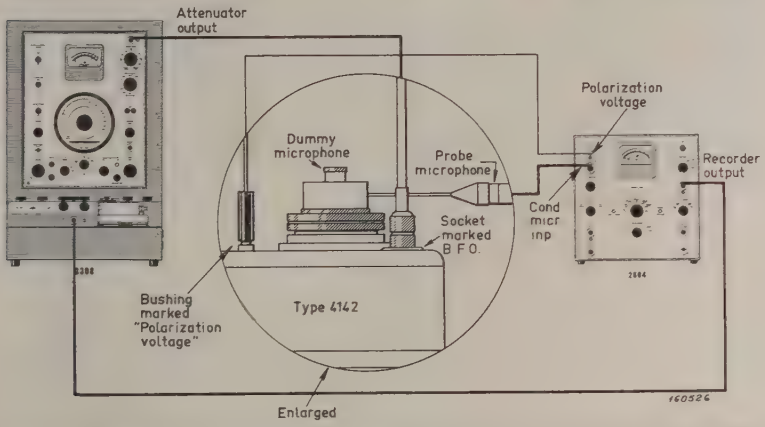


Fig. 2.19. Calibration arrangement using the Microphone Calibration Apparatus ***Type 4142 as sound source.***

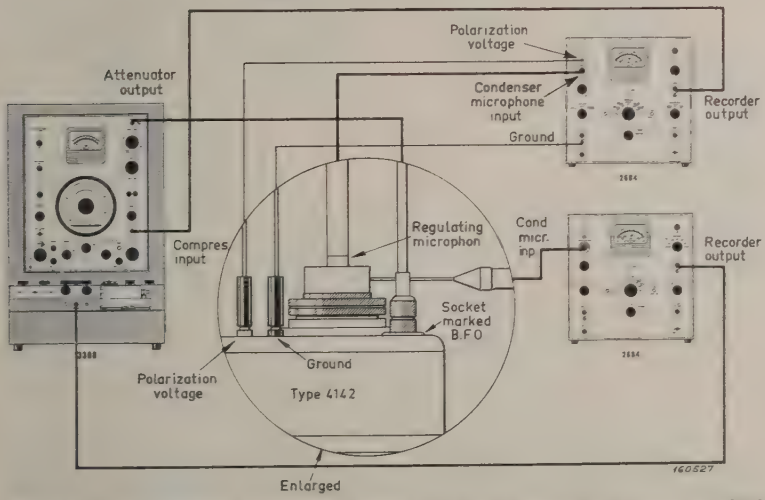


Fig. 2.20. Calibration by means of Type 4142 with regulating circuit applied.

be connected as shown in Figs. 2.21 and 2.22. A 0.005 μF capacitor and a 100 MΩ resistor will give the same operating conditions as in Type 4142.

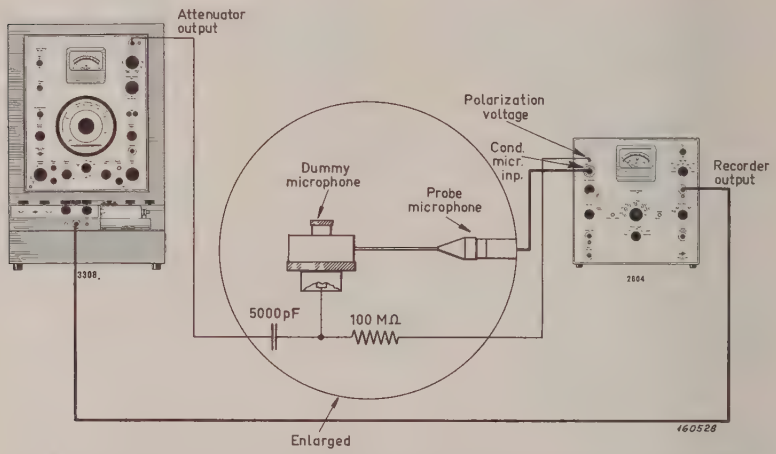


Fig. 2.21. Arrangement using a Condenser Microphone Cartridge Type 4132 or 4134 as sound source.

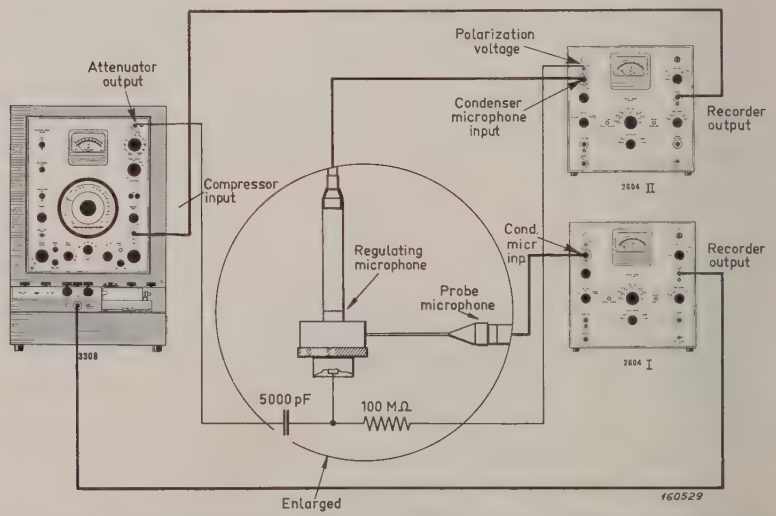


Fig. 2.22. Arrangement using a Condenser Microphone Cartridge Type 4132 or 4134 as sound source, and employing a regulating microphone and compressor circuit.

Microphone Stand.

The Microphone Stand UA 0049 fitting all types of B & K microphones will be of invaluable assistance in field measurements, where the microphone should always be placed in an undisturbed region of the sound field, i.e. in most cases remotely from the instruments.

The Stand is a lightweight portable tripod of rugged construction. It has rigid telescopic legs and can be used not only for supporting the B & K microphones but also for the somewhat heavier Precision Sound Level Meter Type 2203.

Fig. 2.23. The Microphone Stand UA 0049.

Extension Cables.

Several standard lengths of extension cable are available, the cables being specially designed and supplied with B & K microphone connectors at both ends. Each conductor is insulated with polyethylene and the outside cover of the cable is a coating of grey coloured P.V.C.

Due to the very low capacity and extremely good shielding of the cables, several lengths can be coupled together without influencing the frequency range of the measuring arrangements. For very long cables, however, the effect of cable capacity upon the distortion and frequency response of the overall measuring arrangement is not always negligible. See Fig. 1.11. The filament series resistor included in the microphone power supply should then also be adjusted so that the filament voltage on the cathode follower tube is 6.3 volts.

Extension Cable Type	*AO 0027*	*AO 0028*	*AO 0029*
Length	3 m (10ft)	10 m (33 ft)	30 m (100 ft)
Diameter	6 mm (¼″)	9 mm (⅜″)	9 mm (⅜″)
Capacity to ground of the signal conductor	300 pF (100 pF/m)	570 pF (57 pF/m)	1700 pF (57 pF/m)

Tape Microphone Cable AR 0001. This very flexible, flat 7-cored microphone cable is used when sound insulation and reverberation measurements are made in buildings and where it is necessary to carry a microphone cable through closed windows and doors. The flat cable can easily follow sharp bends, the thickness of the cable being 0.2 mm. Cable length: around 30 cm.

Adaptor UA 0030.

This adaptor is designed to enable the use of a 23.77 mm cathode follower (Type 2612-13 or 2630) in connection with a ½″ microphone cartridge. The adaptor extends the "guard ring" system of the cathode follower in order to obtain a minimum input capacity. However, a small decrease in sensitivity (around 0.15 dB) may be noticed, while the low frequency cut-off of the microphone is raised about one octave up due to the lower input impedance of the 23.77 mm cathode follower.

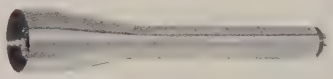


Fig. 2.24. Adaptor UA 0030.

Flexible Extension Rod UA 0039.

This adaptor introduces a flexible goose-neck between a 23.77 mm cathode follower (Type 2612-13 or 2630) and the microphone cartridge. It is designed for use with ambient temperatures up to 150°C, and it accepts both the 1″ and the ½″ microphone on the input end. It extends the "guard ring" system of the cathode follower in the same manner as UA 0030. Total length: 46 cm (1½ foot). Input impedance of Type 2612/13 or 2630 + UA 0039: 270 MΩ shunted by 6 pF.

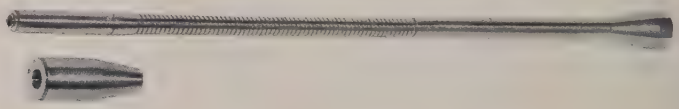


Fig. 2.25. Flexible Extension Rod UA 0039.

Flexible Adaptors UA 0122 and UA 0123.

The flexible Adaptors UA 0122 and UA 0123 have been designed for use with the B & K 1/2″ Microphones (4133—4134) as well as the 1/4″ Microphones (4135—4136). They consist basically of a flexible rod and three mechanical

Fig. 2.26. The Flexible Adaptor UA 0122.

mounting pieces, see Figs. 2.26 and 2.27. At one end of the rod is placed a mounting arrangement for attachment to a Cathode Follower Type 2615 (or 2614) and at the other end the Microphone cartridge itself can be mounted. UA 0122 allows side mounting of the cartridge while UA 0123 is designed for end mounting.

Both Adaptors make use of the well known B & K double screening system which reduces the input capacity, and thus its influence on the microphone characteristics, to a minimum. The increase in input capacitance caused by the Flexible Adaptor is of the order of 2 pF. As insulation materials are used teflon and silione treated rubber and the inner one of the two screens is of a special mini-noise type.

The 1/4″ Microphones can be mounted directly on the Adaptors while the 1/2″ Microphones require the use of a mechanical conversion arrangement.

Fig. 2.27. The Flexible Adaptor UA 0123.

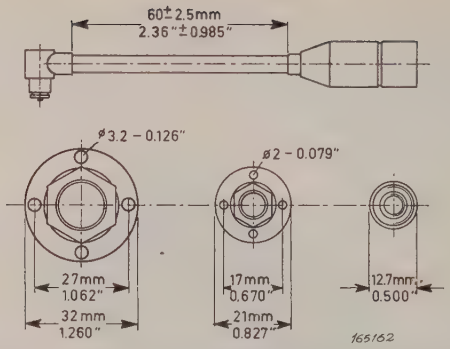


Fig. 2.28. Sketch of the flexible rod and the flush mountings contained in UA 0122.

which is supplied with the Adaptor. Also supplied with the Adaptor are two flush mounting pieces one for the 1/4″ Microphone and one for the 1/2″ Microphone. The flush mountings are designed with the smallest possible heights.

It is recommended when the Microphone and Flexible Adaptor are mounted on the Cathode Follower to calibrate the complete arrangement by means of a Pistonphone Type 4220 if accurate measurements are to be made.

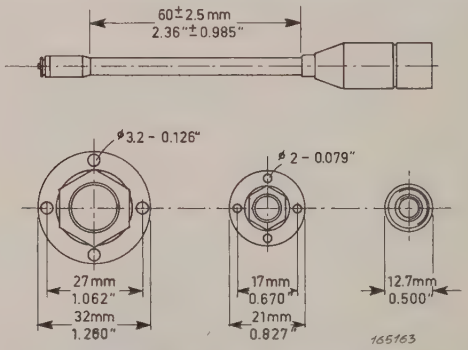


Fig. 2.29. Sketch of the flexible rod and the flush mountings contained in UA 0123.

Coupler Mounting.

By means of the Mechanical Adaptor DB 0225, the half-inch microphones may be mounted in the different B & K couplers which are designed for the one-inch microphones (Cartridges 4131-32). The mechanical adaptor DB 0225 gives the Cartridges 4133-34 the same external dimensions as the Cartridges 4131-32. Three couplers corresponding to the specification of the American standards are available:

(1) 2 cm³ Coupler Type DB 0138 (Z 24.9.1949 and IEC)
(2) 6 cm³ Coupler Type DB 0160 (N. B. S. type 9A)
(3) 6 cm³ Coupler Type DB 0161 (Z 24.9.1949, type 1).

A 0.3 cm³ coupler is also available as accessory for Type 4142 and is described in the respective instruction manual.

By screwing the coupler adaptor ring type DB 0111 on the "one-inch" or "half-inch + DB 0225" cartridge (Fig. 2.30) a 0.936" — 23.77 mm diameter microphone is obtained which allows measurements to be made in complete agreement with the standards. See the Manual for the Artificial Ear Type 4152.

Note: The gas contained in the coupler also fills the microphone cartridge. If the gas density differs markedly from that of air at atmospheric pressure, a change in damping and in frequency response is to be expected.

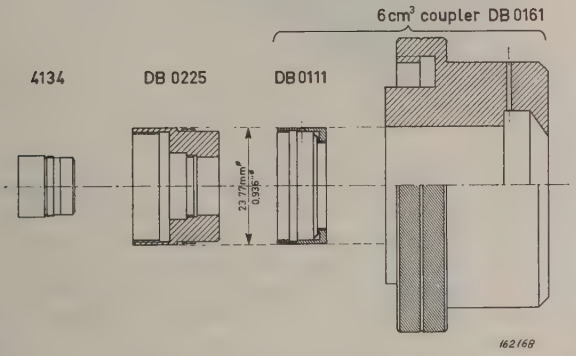


Fig. 2.30. Mounting of a half-inch microphone in the 6 cm³ coupler corresponding to the American Standard Z 24-9-1949.

The Two Channel Microphone Selector Type 4408.

The Two Channel Microphone Selector Type 4408 is designed especially for use with B & K condenser microphones and enables the output from one or the other of two microphones to be alternately switched to the input of a single amplifier. A recording of two phenomena, e.g. the sound pressure at two different points in a sound field, can thus be obtained on a level recorder. The microphone selector is mounted in a metal case as shown in Fig. 2.31 and contains a toggle switch for manual operation of a relay, which selects one or other of the microphone inputs. The relay is powered from the microphone power supply.

The selector may also be remotely controlled. The toggle switch is then switched to position "2", and an external control switch connected to the

terminals marked "External Control". The external switch then replaces the function of the toggle switch. The simultaneous recording of the two signals may thus be driven from the Level Recorder Type 2305 which is provided with a switch operated in synchronism with the paper drive.

N.B.: The heater supply wiring in the 4408 provides for series connection of the cathode follower heaters and one cathode follower cannot, therefore, be used singly with this instrument.

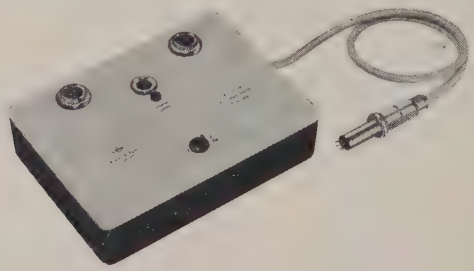


Fig. 2.31. The Two-Channel Microphone Selector Type 4408.

Microphone Power Supply Type 2801.

The Microphone Power Supply is for example used in conjunction with tape recording of measurement data in the field in cases where B & K Amplifiers or Analyzers are not available, or where extremely long extension cables must be used between the microphone and the succeeding amplifier. The power supply unit supplies the necessary filament, anode and polarization voltage for the microphones, and, in addition, it contains a transformer stage to convert the output impedance of the cathode follower into impedance of 50 ohms (voltage ratio 1/6.3) or 200 ohms and 200 ohms symmetrical (voltage ratio 1/3.16).

The power supply unit is heavily stabilized for variations in mains voltage

Fig. 2.32. The Microphone Power Supply Type 2801.

and may be operated from power outlets with 100—115—127—150—220 or 240 Volts (50 to 400 Hz).
The Microphone Power Supply can also be employed in conjunction with the above mentioned Microphone Selector Type 4408. For further details the reader is referred to the separate instruction manual for Type 2801.

Battery-driven Cathode Follower Type 2630.

The Cathode Follower Type 2630 is designed in accordance to the same principles as the Cathode Followers Type 2614 and 2615, but includes in its housing a transistorized power supply delivering the necessary polarization, plate and filament voltages from three small mercury cells. The external diameter of the housing is 23.77 mm (0.936″) at the front, the same as the Microphone Cartridges Type 4131/32 and its total length is 27 cm (11″). A small moving coil voltmeter is also included for checking the batteries' output voltage. The 2630 is equipped with a 3 m (10 ft) long cable at its output. It is delivered with 3 Mallory RM.1-R cells (continuous service life around 20 hours) and an input adaptor for connection of accelerometers etc.
A typical application of the battery-driven cathode follower is the recording in the field of noise or other fluctuating sound pressures by means of transistorized tape recorders, enabling frequency- and statistical analyses to be carried out later in the laboratory. The half-inch cartridges Type 4133-34 may be readily mounted on the 2630 by means of the Adaptor UA 0030 described above. The overall characteristics of a microphone consisting of Types 4133, UA 0030, 2630 are the same as the ½″ microphone 4133 + 2615 with the exception of the low frequency cut-off which is raised about one octave up on account of the lower input impedance of the cathode follower (270 MΩ), and also the 4 % distortion limit of the dynamic range. The latter is around 154 dB (10 V) at 1 kHz if the 2630 is loaded by an impedance of 100 kΩ (the output impedance of 2630 is 300 Ω). The sensitivity loss which is of the order of 0.15 dB may be neglected. The influence of temperature on gain is less than ± 0.4 dB in the range —5°C to + 60°C.

Fig. 2.33. The Battery-driven Cathode Follower Type 2630.

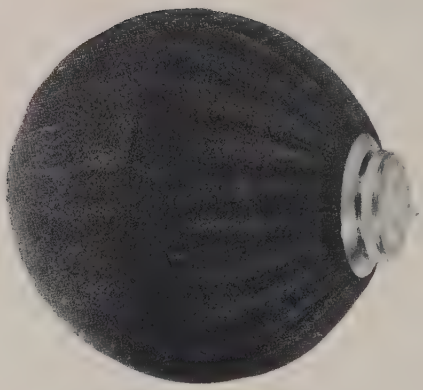
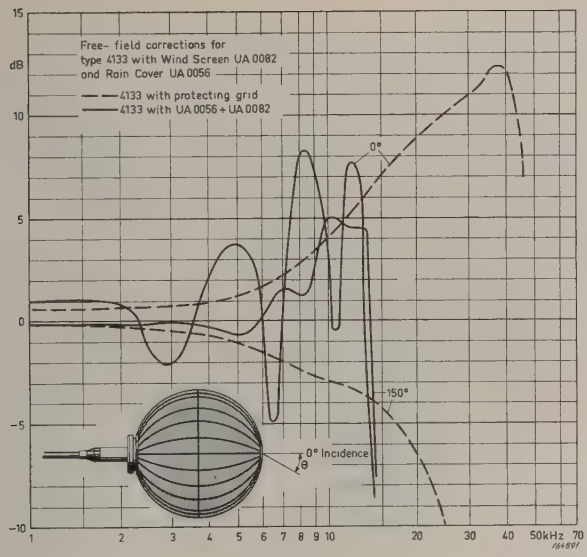


Fig. 2.34. The Wind Screen UA 0082.

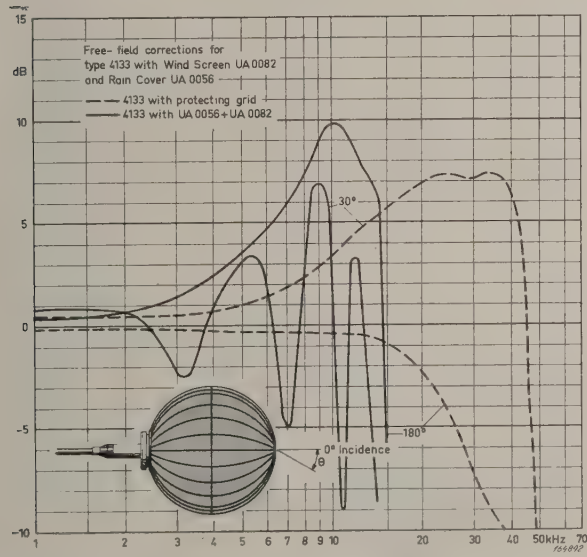
Wind Screen.

The wind screen is designed for mounting on the cathode follower equipped with a condenser microphone cartridge and the rain cover. It is covered with a double layer of nylon cloth, and gives an effective reduction, of the order of 10 dB or higher of wind induced noise at lower wind velocities. It is possible to mount the 1", 1/2" or 1/4" microphone inside the wind screen, but when mounting a 1/2" or a 1/4" microphone and cathode follower a tightening ring and mounting tube must be used. The mounting tube is isolated from the microphone and cathode follower housing in order to avoid a disturbing ground loop, and it is rhodium plated for corrosion protection. When using the wind screen with the rain cover screwed onto the microphone cartridge, the signal lead to the electrostatic actuator inside the rain cover is fed through a slot in the tightening ring.

Shown in Fig. 2.35 is the free-field corrections for a microphone cartridge Type 4133 and cathode follower equipped with a rain cover and mounted inside the wind screen.

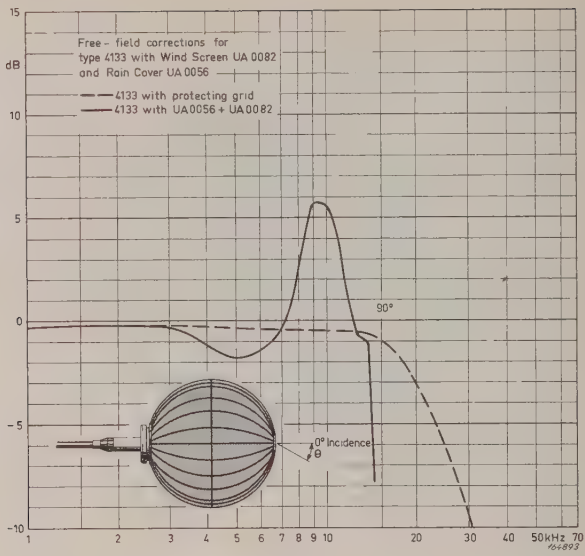


a)

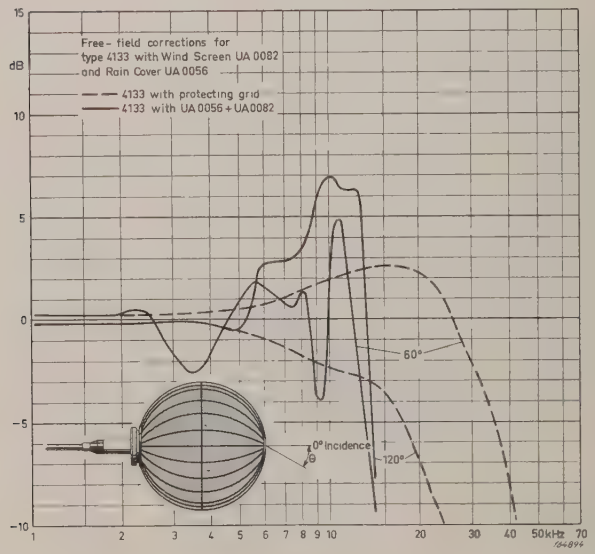


b)

Fig. 2.35. ***Free*** *field corrections for Microphone Cartridge Type 4133 and Cathode Follower equipped with a Rain Cover and mounted inside a Wind Screen.*


Free - field corrections for
type 4133 with Wind Screen UA 0082
and Rain Cover UA 0056
4133 with protecting grid
4133 with UA0056 + UA0082
dB
15
10
5
0
-5
-10
90°
0° Incidence
θ
1
2
3
4
5
6
7
8
9
10
20
30
40
50kHz
70
164893

c)


Free - field corrections for
type 4133 with Wind Screen UA 0082
and Rain Cover UA 0056
4133 with protecting grid
4133 with UA 0056 + UA0082
dB
15
10
5
0
-5
-10
60°
0° Incidence
θ
120°
1
2
3
4
5
6
7
8
9
10
20
30
40
50kHz
70
164894

Appendix

Microphone Calibration.

Determination of the Error in an Absolute Sound Level Measurement.

Considering the various standard*) errors a, b, c - - - which are expected to occur on each of all the different parts of the measuring arrangement, the total standard error is $S = \sqrt{a^2 + b^2 + c^2 + \text{- - - -}}$

In the case of the measuring arrangement of Fig. 1.2, for example, the different errors to be considered in the measurement of the sound pressure level on the microphone diaphragm are as follows (rough estimation):

(a) Microphone cartridge calibration: 0.2 dB after proper corrections.
(b) Transmission loss of the cathode follower and loading of the cartridge: 0.1 dB.
(c) Polarization voltage's deviation from 200 V: 0.2 dB.
(d) Voltage calibration of the 2603: 0.1 dB.
(e) Meter scale and attenuators: 0.2 dB.
(f) Reading error: 0.1 dB.
(g) Uncertainty on the frequency response of the measuring equipment, which should be taken into account when considering bands of noise having frequencies differing greatly from the frequency of microphone calibration (250 Hz). Still considering the equipment of Fig. 1.2, this uncertainty is about ± 0.1 dB from 50 Hz to 2 kHz, and ± 0.3 dB from 30 Hz to 10 kHz for a free-field measurement at 0° incidence with the 4133 or at 90° incidence with the 4134. When measuring broad band noise through the A-B-C weighting networks of the 2603 the probable frequency response uncertainty is of the order of ± 0.3 dB.

Equating 0.1 dB to 1.1 %, 0.2 dB to 2.2 % and 0.3 dB to 3.3 %, the standard error in the measured result will thus be

$$S = \sqrt{2.2^2 + 1.1^2 + 2.2^2 + 1.1^2 + 2.2^2 + 1.1^2 + 3.3^2} = \pm 5.4\ \% = \pm 0.48\ \text{dB}$$

Note: In some cases of irregular statistical distribution of signal amplitudes, errors may be caused by the limited averaging time (damping) of the meter or by the limitation of the RMS rectifier possibilities.

If a better accuracy is wanted, the most practical and reliable solution is to make a direct calibration of the whole measuring arrangement before each series of measurement by means of a calibrated sound source. Then the errors (a) (b) (c) (d) outlined above are replaced by the source calibration error and the calibration reading error. When using a Pistonphone Type 4220, these errors may be estimated each to 0.1 dB. The total standard error is then reduced to S = 0.40 dB (0.27 dB for pure tones for which error (g) may be eliminated).

*) The standard error s is such that there is 68 % chance of obtaining errors smaller than s, 90 % smaller than 1.65 s and 99 % smaller than 2.58 s.

Pistonphone Type 4220.
The Pistonphone Type 4220 (Fig. A.1) is a small portable battery-driven unit weighting only 1.5 lbs, which is extremely well-suited for field calibration. When fitted to any B & K Microphone a sound pressure level of 124 dB is obtained at 250 Hz with less than 3 % distortion. Each pistonphone is individually calibrated within ± o.2 dB. A barometer is supplied with the instrument for direct reading of ambient pressure corrections together with various adaptors for direct fitting to the different B & K microphones.

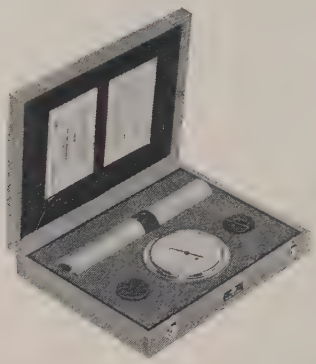


Fig. A.1. The Pistonphone in case with Barometer and Coupler Adaptors for B & K Microphones.

Microphone Calibration Apparatus Type 4142.
An even better accuracy may be obtained by the reciprocity technique, which is the method retained by the American Standard Association (Z 24.4.-1949). This method is relatively time-consuming and is employed mainly for calibration of standard microphones. The long-term stability of the cartridges Type 4133-4134 has proved to be excellent over several years, which means that they can be used as primary standards in calibration laboratories. The Microphone Calibration Apparatus provides all the accessories which are needed for carrying out the reciprocity calibration of the B & K microphones in combination with a Beat Frequency Oscillator and a Microphone Amplifier. See the measuring set-up in Fig. A.2. Three different coupler volumes are available: 20, 3, and o.3 cm^3 usable up to 20 kHz (60 kHz when hydrogen filled). In addition, Type 4142 includes two electrostatic actuators (Types UA 0023 and UA 0033) for frequency response calibration of B & K condenser microphones and provides stabilized 800 V polarization voltage for use with the actuators.
The "half-inch" **Electrostatic Actuator Type UA 0033** (Fig. A.3) may be used separately when only the frequency response is to be investigated. The actuator is placed on the microphone cartridge held vertically. It has three glass studs which contact the periphery of the cartridge diaphragm in order

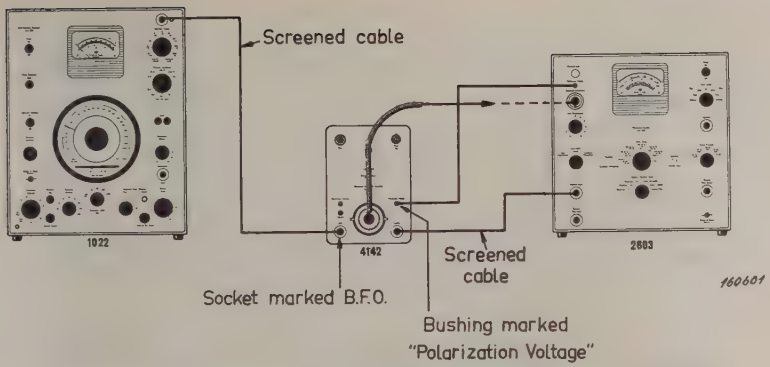


Fig. A.2. Measuring set-up for the reciprocity calibration of a B & K microphone.

to obtain an accurate definition of the spacing between actuator grid and diaphragm. By applying an AC voltage between the grid and the diaphragm a fictive sound pressure proportional to the square of the voltage (at double frequency) is obtained. When using a B.F.O. Type 1022 the maximum available voltage of 120 V will provide an equivalent sound pressure level of about 80 dB which remains constant from 40 Hz to 40 kHz. Proper use of the Actuator enables the frequency response uncertainty outlined above to be reduced to less than o.1 dB. Higher sound level may if necessary be obtained by using the 800 volts DC bias provided by the 4142.

Since the fictive pressure is not affected by ambient conditions, the actuator is also an excellent means for the determination of the variations in microphone sensitivity under changing environments.

Fig. A.3. Electrostatic Actuator UA 0033.

The Range of B & K Condenser Microphones.

Compared characteristics of the different types of condenser microphones made by B & K are summarized in the figures and tabels below. They are all of similar construction, but differ in dimensions, the smaller diameters giving higher limits of the frequency and dynamic range at the expense of a lower sensitivity.

For detailed description, the reader is referred to the respective Instruction Manuals. However a rough estimation of the general characteristics of all types may be obtained by extrapolation of the characteristics described in this manual for the half-inch microphones.

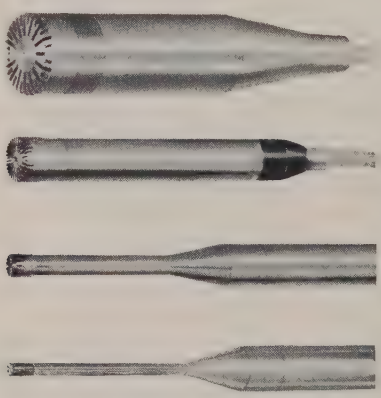


Fig. A.4. From top to bottom:
Type 4131/32 + 2613 (23.77 mm outside diameter
Type 4133/34 + 2615 (12.7 mm outside diameter)
Type 4135/36 + UA 0035 + 2615 (6.35 mm outside diameter)
Type 4138 + UA 0036 + 2615 (3.175 mm outside diameter)

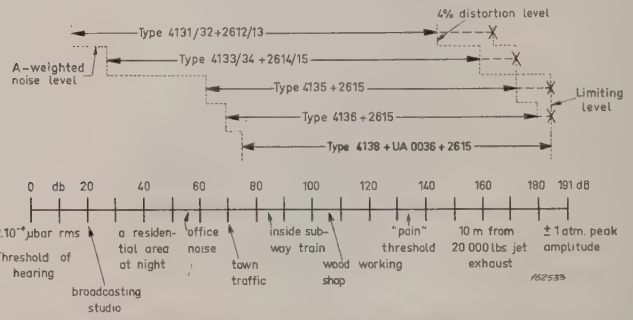


Fig. A.5. Compared dynamic ranges of the B & K condenser microphones.

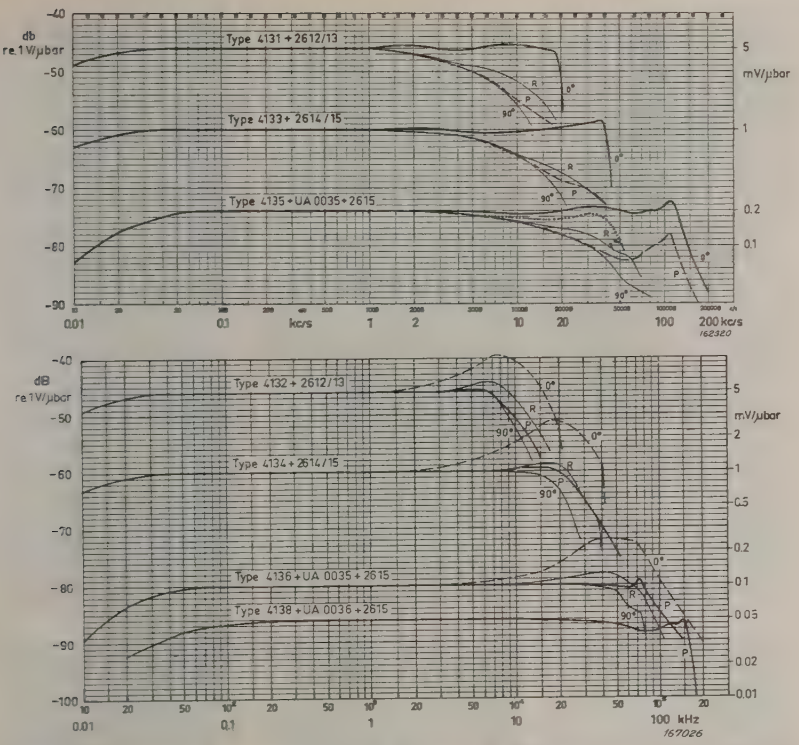
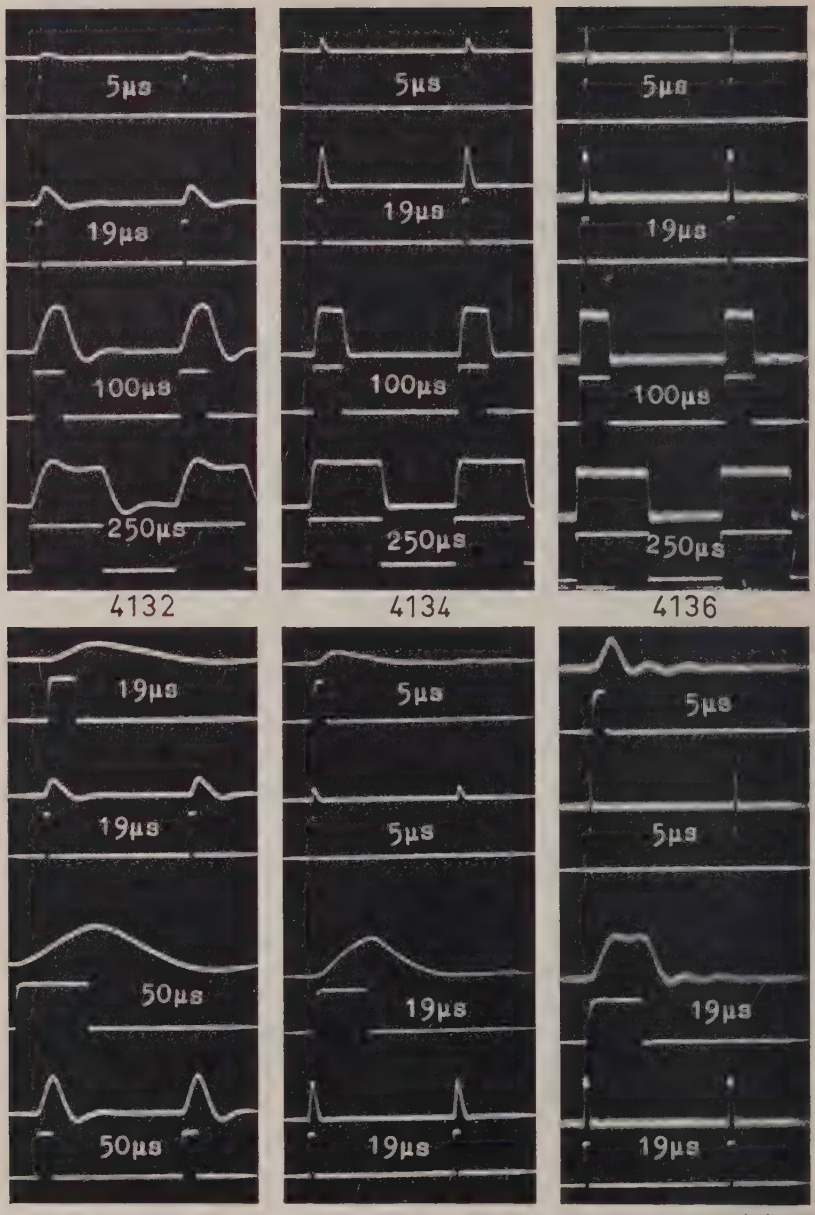


Fig. A.6. Frequency response of the different B & K condenser microphones (without accessories).

0° = free-field response at 0° (normal incidence).
90° = free-field response at 90° (grazing incidence).
R = random incidence response (diffuse field).
P = pressure response (towards higher frequencies, the slope is about 12 dB/octave).

NB. Valid with protecting grid for types 4131—34 (1" and ½") and without protecting grid for types 4135—36 (¼") and 4138 (⅛") with exception of the dotted "R-curve" of 4135 which is with grid.

Fig. A.7. Compared pulse-response of the B & K microphones. →
From left to right: 1" (4132), ½" (4134) and ¼" (4136).
The microphone is actuated electrostatically by positive rectangular pulses at a pulse recurrence frequency of 2000 Hz with different crest factors (peak amplitude/rms value). Input pulses are represented under the corresponding output pulses.
Above, from top to bottom: crest factors of 10, 5, 2 and 1. (Pulse duration: 5, 19, 100 and 250 µs).
Below: enlarged pulse pictures with horizontal scanning velocity multiplied by 5 for the 4132 and 10 for 4134 and 4136. Unenlarged pictures are represented under the corresponding enlarged pictures. Crest factors 3 and 5 for the 4132 and 5 and 10 for 4134-4136 are enlarged and show that the condenser microphones have practically no ringing.


5µs
19µs
100µs
250µs
4132
5µs
19µs
100µs
250µs
4134
5µs
19µs
100µs
250µs
4136
19µs
19µs
50µs
50µs
5µs
5µs
19µs
19µs
5µs
5µs
19µs
19µs
162565

Survey of the Catalogue-listed Accessories available for each Microphone Series (1", 1/2", 1/4", 1/8" diameter)

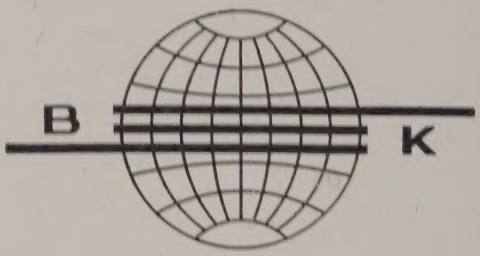
Description		1" Type	1/2" Type	1/4" Type	1/8" Type
Microphone Cartridge		4131-32	4133-34	4135-36	4138
Cathode Follower	goose-neck type with 2 m long cable with Junction Box ZH 0007 battery driven	2612 2613 2617 2630	2614 2615 26303)	26141) 26152)	26147) 26157)
Front Covers	Random incidence corrector Wind screen Nose cone Rain cover Probe microphone kit	UA 0055 UA 0082 UA 0051	 UA 0082 UA 0052 UA 0056 UA 0040	 UA 0053 UA 00404)	 UA 00408)
Mountings	Flexible Adaptor (for side-mounting) Flexible Aadaptor (for end-mounting Extension Connector (fitting 2612-13-30)	 UA 0039	UA 0122 UA 0123 UA 0039	UA 0122 UA 0123	
Calibration	Electrostatic actuator	UA 0023	UA 0033	UA 00334)	UA 00338)
	Pistonphone	4220			
	Reciprocity calibration Apparatus	4142			
Acoustical Couplers	Artificial mouth Artificial ear 6 cm3 ASA-Z 24.5.1951 6 cm3 ASA-Z 24.9.1949 2 cm3 IEC 126-1961 Coupler adapting ring	4152 DB 0160 DB 0161 DB 0138 DB 0111	4216 41525) DB 01605) DB 01615) DB 01385)		
Cartridge extension cable (3 m, for use with 2203)		AO 0033			
Extension cables (3 m - 10 m - 30 m) Tape microphone cable (o.3 m)		AO 0027-28-29 AR 0001			
Microphone stand		UA 0049			
Microphone power supply		2801			
Two-channel power supply		2803			
Two-channel microphone selector		4408			
Sound measuring equipment6)	Portable sound level meter	2203	22033)		
	Portable octave filter set	1613			
	Sound level meter Spectrometer (1/1 and 1/3 octave) Frequency analyzer	2603 - 2604 2112 - 2211 - 2212 2107			

1) Add Adaptor UA 0035.
2) Add Adaptor UA 0035.
3) Add Adaptor UA 0030 or UA 0039 or AO 0033.
4) Add 1/4"—1/2" Adaptor DB 0264.
5) Add 1/2"—1" Adaptor DB 0225.
6) Following the recommendations of the IEC for Precision Sound Level Meters.
7) Add Adaptor UA 0036.
8) Add Adaptor DB 0900.

COMPARATIVE SPECIFICATIONS

Type	4131 + 2612/13	4132 +2612/13	4133 +2614/15	4134 +2614/15	4135 + UA 0035 + 2615	4136 + UA 0035 + 2615	4138 + UA 0036 + 2615
Nominal Cartridge Diameter	1 inch		½ inch		¼ inch		⅛ inch
Frequency Response*) See Fig. 3. Flat within ± 2 dB in the range:	**Free-field (0° incidence)** 20 Hz to 18 kHz	**Pressure** 20 Hz to 7 kHz	**Free-field (0° incidence)** 20 Hz to 40 kHz	**Random incidence and Pressure** 20 Hz to 20 kHz	**Free field (0° incidence)** 30 Hz to 100 kHz	**Random incidence and Pressure** 30 Hz to 70 kHz	**Random incidence and Pressure** 30 Hz to 140 kHz
Sensitivity*) at cathode follower output	5 mV/μbar –46 dB re. 1 V/μbar		1 mV/μbar –60 dB re. 1 V/μbar		0.2 mV/μbar –74 dB re. 1 V/μbar	0.1 mV/μbar –80 dB re. 1 V/μbar	50 μV/μbar –86 dB re. 1 V/μbar
Cartridge open-circuit sensitivity*)	–45 dB re. 1 V/μbar		–58 dB re. 1 V/μbar		–70 dB re. 1 V/μbar	–76 dB re. 1 V/μbar	–86 dB re. 1 V/μbar
Dynamic Range (from equivalent A-weighted noise level to 4 % harmonic distortion)	15–146 dB re. 0.0002 μbar		32–160 dB re. 0.0002 μbar		64–174 dB (10 %) re. 0.0002 μbar	70–180 dB (10 %) re. 0.0002 μbar	76–184 dB (10 %) re. 0.0002 μbar
Resonant Frequency (90° phase angle)	10 kHz	8 kHz	25 kHz	25 kHz	75 kHz	75 kHz	
Polarization Voltage	200 V						
Polarized Cartridge Capacity*)	70 pF	60 pF	20 pF		6.4 pF		
Equivalent Air Volume (at 1 atm.)	0.15 cm^3	0.15 cm^3*)	0.01 cm^3	0.01 cm^3*)	0.0005 cm^3		< 0.0001 cm^3
Temperature Range: up to	100°C	100°C	with 2614: 150°C (continuous) 250°C (intermittent) with 2615: 100°C (limited by cable insulator)				
Temperature coefficient between –50°C and +60°C	less than ± 0.01 dB/°C						
Ambient Pressure Coefficient (increase of sensitivity for a 100 mm Hg decrease of pressure)	0.2 dB		0.1 dB		less than 0.1 dB		
Relative humidity influence	less than 0.1 dB (in the absence of condensation)						
Dimensions of cartridge: without protecting grid with protecting grid	diameter / height 23.77 mm (0.936") / 17 mm (0.67") 23.77 mm (0.936") / 19 mm (0.75")		diameter / height 12.7 mm (½") / 11 mm (0.43") 13.2 mm (0.52") / 12.7 mm (½")		diameter / height 6.35 mm (¼") / 9 mm (0.35") 7 mm (0.275") / 10.5 mm (0.41")		diameter / height 3.175 mm (⅛") / 6.0 mm (0.240") 3.50 mm (0.140") / 6.7 mm (0.268")
Thread: grid (or coupler) mounting cathode follower mounting	23.11 mm (0.91") – 60NS2 23.11 mm (0.91") – 60NS2		12.7 mm (0.50") – 60NS2 11.7 mm (0.46") – 60NS2		6.35 mm (0.25") – 60NS2 5.7 mm (0.22") – 60NS2		M 3.175 × 0.2 M 3 × 0.25

*) Individually calibrated.



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